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TABLE OF CONTENTS:

(16 *pages and inset.*)

ENGINEERING NEWS OF THE WEEK.....205, 217
Repairs to the Battleship "Oregon" at the Puget Sound Navy Yard (illustrated)..... 206
A Few Notes on the Use of the Plane-Table for Rapid Survey Work..... 207
A Modern Steel Derrick Car for Bridge Erection (illustrated)..... 208
New Construction Work on the Pennsylvania R. R.. 209
Time Lock to Prevent Derailments at Interlocked Grade Crossings (illustrated)..... 210
A Report on the Vibration from the Central London Ry..... 210
A Novel Design for an Earth Dam (illustrated)..... 215
Notes from the Engineering Schools..... 217
Construction of the Forbes Hill Reservoir and Stand-Pipe at Quincy, Mass. (with two-page plate and other illustrations)..... 217
EDITORIAL NOTES..... 212
A Comparison of Deaths by Lightning and Deaths of Passengers in Railway Accidents—Moving Sidewalks for Transporting Passengers on the East River Bridges—Is an Extension of a Bridge Approach a Street Railway?—Missing: The Savannah Harbor Contractors.
EDITORIAL:
Should Executive Officers Be Held Criminally Responsible for Accidents?..... 212
LETTERS TO THE EDITOR.....213-215
Monolithic Concrete Sewers—A Bad Way to Get Rid of the Waste Water from House Refrigerators—Derails and "Sand Tracks" on Inside Tracks at Crossings—Could an Asphalt Diaphragm in an Earth Dam be Relied On?—Priming Centrifugal Pumps Handling Muddy Water (illustrated)—Cost of Building Macadam Roads—Slide-Rule Computations for Laying Out Curves—The Inventor of the T-Rail (illustrated)—Mr. Worthington's Design for a Non-Continuous Swing Bridge—Notes and Queries.

THE NEW WORKS FOR THE WATER SUPPLY of Jersey City, N. J., will probably be completed by the East Jersey Water Co. The original contract was made on Feb. 28, 1899, between the city and Mr. Patrick H. Flynn, of Brooklyn, who assigned his contract to the Jersey City Water Co. The latter company is behind on its contract and has been unable to raise money, independently, for its completion. The East Jersey Water Co., and allied interests, have offered to furnish $3,280,000 to finish the work, and to assume charge of the work, provided the city will waive the penalty for non-fulfilment within the contract time and extend the time until Dec. 25, 1903. The East Jersey Water Co. offers also to continue its temporary supply from the Lower Passaic at Little Falls until the Rockaway River works are completed. Inasmuch as the company has already notified Jersey City that it will discontinue the temporary supply in a few months, and since the old contractor is unable to go ahead with the work, it looks as though Jersey City would be obliged to accept the proposition of the East Jersey Water Co. If so, the company will at last attain an object for which it worked hard for many years.

THE CHICAGO CONCRETE TUNNELS, being built by the Illinois Telephone & Telegraph Co., and described in our issue of May 2, 1901, are to be used, it seems, for other purposes than the accommodation of wires and cables for a new telephone system, and for the city police and fire-alarm system. It is now proposed to utilize the narrow-gage tracks for carrying newspapers and mail matter between the railway stations and the post offices and newspaper offices. Eventually a freight handling system may be established. As shown by the map in the article above referred to, the tunnels will practically honeycomb the business section of the city and extend through the north, west and south sides of the city. Some of those under the main streets are 12 ft. wide and 14 ft. high, although many are only 6 × 7½ ft. The tracks are of 14-in. gage. About 1,200 men are now employed, working from numerous headings which are accessible from a number of shafts. Mr. George J. Jackson is Engineer and Manager for the Illinois Telephone Construction Co.

STEEL OIL TANKS OF LARGE DIMENSIONS have been ordered by the San Antonio & Aransas Pass R. R. Co. for use in supplying oil-fuel to the engines of that road. Two of these tanks will each hold 55,000 barrels of oil, and four will have a capacity of 30,000 barrels each. The location of these tanks has not yet been fixed upon. This 9,000,000 gallons of oil will supply fuel for eight months to 60 engines, according to the estimates made. They will be filled during the dull season. The engines will be equipped with oil burners as rapidly as the material can be secured.

FLOODS FROM MELTING SNOW have caused great damage in many parts of the country during the past three weeks. Heavy falls of snow, combined with high temperature and rain in the eastern section, caused high water and floods in the whole Appalachian region. Bridges and railway embankments were carried away and large stretches of country inundated. The damage was especially great in New York, New Jersey and Pennsylvania. Two serious wrecks with fatal results were noted in our issue of March 6, both caused by high water; a large number of other, less serious, wrecks during the past few weeks must also be charged to this cause. Some snow-slides in Colorado attended with much loss of life were noted in our issue of March 6, and these were due to the same weather conditions.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred early on the morning of March 7 on the Southern Pacific Ry., near Maxon, in the southwestern part of Texas. A westbound passenger train was derailed on a sharp curve, and the wreck took fire. Eight coaches, including four sleepers, were burned. The number of the killed is not accurately known, but it is probably between 15 and 20. Of these, some were killed outright and some were held in the wreck and burned to death. A number of persons, at least 25, suffered injuries more or less severe. The cause of the derailment is in doubt; a broken rail, an obstruction on the track, and high speed down a steep grade to make up lost time are among the causes advanced.

THE AMERICAN LINER "WAESLAND" WAS SUNK on March 6 by a collision with the British steamship "Harmonides," bound from Para to Liverpool, off Holyhead, on the west coast of Wales. The "Waesland" had left Liverpool the day before, bound for Philadelphia, and when about 40 miles off Holyhead, in a dense fog, was run into amidships by the "Harmonides," just before midnight. The "Waesland" was in a sinking condition, but the rescue work was carried on in a most orderly manner, and her passengers were speedily transferred to the "Harmonides." Only two persons were killed, both passengers. The "Waesland" was a single-screw iron steamer of 3,676 tons, built in 1867.

A TIDAL WAVE DID GREAT DAMAGE on the (Pacific) coast of Salvador, in Central America, on March 4. A length of coast of about 100 miles was inundated, and the towns of La Libertad and Acajutla almost destroyed. A large number of lives were lost in the flood, possibly over 100. A volcanic eruption on the bottom of the sea is supposed to have caused the wave.

THE FILTER PLANT AND PUMPING STATION of the East Jersey Water Co., at Little Falls, N. J., were not seriously damaged by the recent floods, newspaper reports to the contrary notwithstanding. Mr. J. Waldo Smith, M. Am. Soc. C. E., Engineer and Superintendent of the East Jersey Water Co., of Paterson, N. J., informs us that the water did not get near the filter plant, and that at the main pumping station the only serious mishap was due to the failure of an old coffer dam, which so flooded the engine house floor that pumping had to be suspended for three or four days.

THE FIRE LOSS of the United States and Canada for February, as compiled by the New York "Journal of Commerce," shows a total of $21,010,500. The Paterson and Waterbury fires account for $6,000,000 of this, which is substantially the amount by which the loss exceeds that recorded for January.

THE LOSS OF LIFE BY LIGHTNING in the United States has been investigated by Mr. Alfred J. Henry, of the U. S. Weather Bureau. Enquiry was commenced in 1890, though the earlier statistics are incomplete. But in the year 1900, 713 persons were killed or received fatal injuries from lightning. Of these, 291 were killed in the open, 158 in houses, 57 under trees and 56 in barns, the circumstances attending the death of the others are unknown. And during the same year 973 persons were more or less injured by the same agency. As the number of deaths depend partly upon the density of population and partly upon the character of the storms in any region, it is found that the greatest number of these accidents occur east of the 100th meridian; the frequency steadily diminishes going westward, and is practically zero on the Pacific Coast. In the ten years, 1890-1900, 3,772 persons were killed by lightning in the United States, or an average of 377 per year. July is the most fatal month, 1,060 of all the deaths noted occurring in that month. The report goes on to discuss the phenomenon of a lightning flash and the relation of temperature, atmospheric pressure and moisture to the development of thunder storms.

THE CUNARD STEAMSHIP, "ETRURIA," on Feb. 26, while bound from New York to Liverpool, lost her propellor, and with it her steering gear. On the evening of the same day the steamship "William Cliff" was signalled and an arrangement was made to tow the "Etruria" to Fayal, in the Azores, where she arrived on March 9. The passengers and crew will be sent to Southampton on the steamship "Elbe."

BRIDGE RENEWALS on the Union Pacific Ry. are being carried out very extensively. Nearly all the old iron bridges on the main line, built between 1878 and 1882, have been replaced with modern structures, and the timber trestles and bridges are being replaced with modern steel structures. Plate girders are used for spans up to 95 ft.; lattice trusses for 110 ft. to 150 ft., and pin-connected trusses for longer spans. The longest plate girder spans are of 107 ft. The standard designs of both plate girders and lattice trusses vary by lengths of 15 ft. The old iron bridges are used on the branch lines. Several steel viaducts have also been built, and another is to be built shortly at Kansas City. The renewals on the main line have been made imperative by the introduction of the very heavy locomotives, which are now in regular use. The ten-wheel passenger engines have loads of about 46, 51 and 47 tons on the first, main and third driving axles; while the steel ballast cars loaded with about 60 tons of gravel give axle loads of about 20 tons.

EXPERIMENTS IN WIRELESS TELEPHONY are being carried on by the Signal Corps of the U. S. Army. It is said that a few days ago successful communication was accomplished over a distance of 480 ft. It is expected that the extension to much greater distances is a matter of the near future.

A NEW BRITISH PATENT LAW is now before Parliament which, if enacted, will require a search to be made to determine the novelty of an invention before the issuance of the patent. The search by the terms of the law, however, is to be confined to British patents issued not more than 50 years prior to the date of the application. Patents more than 50 years old are not to be considered as anticipating an invention.

CIVIL SERVICE EXAMINATIONS will be held by the Municipal Civil Service Commission of New York city for the following positions: March 24, transitman and draftsman, maximum salary, $1,320; March 25, topographical draftsman; March 25, marine engineer, salary, $900 to $1,200. Geo. McAneny, Secretary.

TO RELIEVE THE OLD BROOKLYN BRIDGE, or rather, to provide more room for the traffic, Mr. Wm. Hildenbrand, Chief Engineer for John H. Roebling's Sons for the erection of the cables of the new East River bridge, proposes to widen the roadways for vehicles from 18 ft. 9 ins. to 25 ft. 6 ins. He would do this by "letting out" the outer cables, which are now inclined inward, or "cradled," to the extent of 10 ft. The outer cables would thus swing back more nearly to a vertical plane, though they would still "cradle" about 3½ ft., or a little less than the present "cradling" of the inner cables. He finds by calculation that the stress on the cables due to extra load would not exceed 51,000 lbs. per sq. in., whereas Mr. Philbin's engineers considered a stress of 60,000 lbs. perfectly safe. The estimated cost of this widening is less than $500,000, and the work could be done in about nine months. The direct gain would be relief at the bridge entrances by separating the roadways from the trolley tracks and thus avoiding delays to the latter from any accident on the wagonway. As the trolley tracks would be separated by a railing from the wagonway, any speed desired could be maintained by the trolley cars. This separation can not take place under existing conditions.

THE LOUISIANA PURCHASE EXPOSITION will be ready with its buildings for the opening on May 1, 1903, according to the reports of the managers. Contracts have been entered into involving the expenditure of about $2,000,000, and other contracts will be let shortly. The exposition buildings will cover 160,000 sq. ft. more than those at the Chicago World's Fair, and the grounds include 980 acres. All buildings will be cream white on exteriors and colonnades, with color only used on interior walls, or those in shade. For the "Midway"—so popular at other expositions, a "Terrace of the States" will be substituted, made up of groups of statuary representing each of the fourteen states included in the "Purchase."

THE BAGDAD RAILWAY, says the "Levant Herald," will be 1,552 miles long, including branches; the concession granted is for 99 years, and the line must be ready for traffic in eight years. The railway is to be standard gage—4 ft. 8½ ins., with a single track, and the run from Constantinople to Bagdad must be made in 55 hours. The new line would start at Konieh, the southern terminus of the existing Anatolian Railway; touch Adana, already connected by rail with Messina; from Adana northeast through the mountains to Tell Habesch, where a 60-km. branch will connect with Aleppo; then east from Tell Habesch, across the Euphrates and southeast to Mosul; then due south along the right bank of the Tigris, to Bagdad. At the latter point it crosses the Tigris and reaches its terminus at Basra. A branch from Zubeir will later be run to some undetermined point on the Persian Gulf.

REPAIRS TO THE BATTLESHIP "OREGON" AT THE PUGET SOUND NAVY YARD.

About a year ago the famous battleship "Oregon" struck upon an uncharted rock in Chinese waters, and her keel and bottom were very badly damaged. The vessel was repaired, temporarily but securely, by Japanese workmen at the Nagasaki navy yard, and she then sailed for the United States, to be thoroughly overhauled at the Puget Sound Navy Yard. The enormous weight of the vessel and her armament, and the location and extent of repairs necessary, make the execution of the work unusually interesting to engineers. This work was in charge of Mr. Frank W. Hibbs, Naval Constructor, U. S. N., at the Puget Sound Navy Yard; and to him we are indebted for the description given below of the method of making these repairs, and for the material from which the accompanying illustrations are made.

That the extent of the work to be performed may be better appreciated, the following description of the vessel is given. The battleship "Oregon" was built at the Union Iron Works, at San Francisco, Cal., and was launched on Oct. 26, 1893; the contract price of the hull and machinery being $3,222,810. The general dimensions of the vessel are as follows: Length on load water line, 348 ft.; extreme beam, 69 ft. 3 ins.; mean draft, 25 ft. 4½ ins.; displacement, 11,000 tons; gross tonnage, 5,289 tons; net tonnage, 4,174 tons. The "Oregon" is fitted with twin-screw, vertical triple expansion engines and Scotch boilers. Her trial speed was 16.79 knots, with 11.111 I. HP.; normal coal supply, 400 tons, with 1,594 tons bunker capacity; her steaming radius is 5,500 miles. The main battery includes four 13-in. B. L. R., eight 8-in. B. L. R., and four 6-in. R. F. guns. The secondary battery includes 20 6-pdr. R. F., two 1-pdr, R. F., two Colts, and one 3-in. R. F. field gun. She has two Whitehead torpedo tubes. The turret armor is 15 and 6 ins.; the barbettes, 17, 8 and 6 ins. thick. The belt-armor is 18 ins. thick.

On account of the nature and extent of the injury to the vessel's bottom, two objects were sought in the preparation of both the dock and the ship.

First, to support her weight in docking. The injury to the keel was so extensive and of such a nature that it could not be depended upon to support the weight that it should, partly because it was so crushed over a distance of 140 ft. that it was seriously weakened, and partly also because the keel blocks could not be set to take the keel in landing. About in the middle of this distance were located the forward turret with the armor of barbette turret; two 13-in. guns with their mounts and mechanism, and the diagonal bulkhead armor aggregating over a thousand tons, concentrated in a length of about 30 ft.

The second object was to support the weight of this turret, and of the hull, as far forward as the stem, in such a way that the repairs to the bottom could be made without allowing either the forward portion of the hull to droop, or to bring excessive strain upon the framing, or to allow the turret weights to sag between the sides where principally the supports had to be placed.

For the purpose of docking, therefore, extra supports were provided as follows: (1) The cribbing under the vessel's fore-foot was extended almost to the point of the ram, and was built perfectly solid, molded to the exact shape of the keel, which here turns upward for a distance of about 60 ft. to meet the ram.

(2) Three cribs were built to take the hull on each side under the turret, each crib crossing two frames, and one longitudinal.

(3) A row of 12 × 12-in. shores was provided to take the side plating directly under the first strake below the armor shelf, and extending well forward past the end of the belt armor, as far as the crib under the fore-foot.

(4) The keel blocks were doubled the entire length of the vessel; working them 2 ft. apart.

The ship was landed snugly on the large forward crib, and after setting the wale-shores, the keel blocks and turret cribs were wedged by means of divers wherever they did not take; the armor shores were also wedged by the divers; the water having been pumped down gradually until there were but 14 ft. over the keel blocks when the armor shores were set. In the meantime the bilge blocks had been hauled and the lower wale-shores set; and after pumping down, a line of shores was set on every longitudinal to the bilge keels, under which a line of 14 × 14-in. shores were set in wake of the turret. After docking the vessel rested fairly and easily on all supports.

For the purpose of supporting the ship and turrets while repairs were in progress, the following

Fig. 1. Docking the Battleship "Oregon," Puget Sound Navy Yard.

additional shoring was provided: (1) A broad ribband was worked on each side on the first strake of plating below the armor shelf, consisting of two 12 × 14-in. timbers bolted one above the other to the frames and plating, backed by a 5 × 5-in. steel angle-bar riveted to the plating above the ribband. This ribband extended over a length of 62 ft. in the wake of the turret, and formed the landing for the heads of a row of 12 × 12-in. shores spaced 2 ft. apart, and extending nearly vertically downward to the floor of the dock.

(2) Forward of this, but farther down, about on a line with the end of the bilge keel, a row of pop-

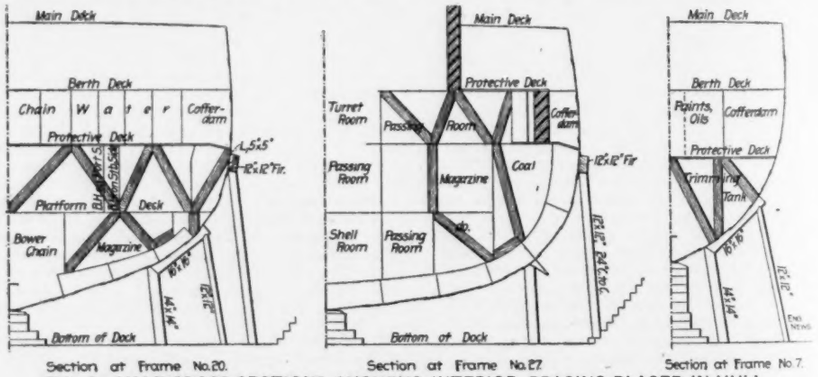

FIG. 2. HALF-CROSS-SECTIONS SHOWING INTERIOR BRACING PLACED IN HULL COMPARTMENTS.

pets were fitted, forming a cradle to carry the weight of the hull to within 20 ft. of the ram. These poppets were worked somewhat similarly to those often used in launching, 14 × 12-in. clamps being secured to the plating, molded to the frame line, to which they were bolted, and each crossing two longitudinals. These clamps were gotten out to shape from the mold loft floor before the ship was docked, and immediately after docking were fitted snugly against the plating, with an angle bar let into them where they crossed the lower edge of a lap.

Each of these clamps formed the landing for two vertical poppets, the lower and inner [illegible] of which, 14 × 14 ins., took on the frame ag[illegible] the heel of the clamp, while the outer, 12 [illegible]in., was nibbed into the head. There were 1[illegible] these double poppets on each side. The piling of [illegible] dock did not come exactly in line with th[illegible]ppet shores, and they were consequently heel[illegible] 14 × 14-in. timbers laid fore and aft on the [illegible] of the dock.

(3) In order to carry on the repairs to [illegible] bottom it was necessary that no permane[illegible] supports should be placed closer to the ke[illegible]han the fourth longitudinal or bilge keel. Co[illegible]ntly, provision had to be made to so brace [illegible] hull that it could not change shape when th[illegible] intermediate supports were removed, and parti[illegible]arly to carry the heavy turret and barbette w[illegible]hts outward and downward to the new line of supports. More than this, however, it was im[illegible]ant to prevent any sagging of the turret weigh[illegible] between the latter.

To accomplish this a set of internal shi[illegible] or braces, 8 ins. square, were worked betw[illegible] the decks, in the side magazines, holds, and coal bunkers, on every frame from the fire room bulkhead (abaft the turret) to the foremost poppets. Between the decks, under the barbette, these were worked diagonally in such a way as to form a truss frame on every beam, thus serving to carry the weight of the turret and barbette outward to the cradle at the side. In the lower holds and coal bunkers, beneath these trusses, diagonal shores extended downward ending on those longitudinals against which were set the permanent shores and poppets in the dock.

About 800 of these 8-in. shores were fitted, and this work was done before the vessel was docked in order partly to assist in bracing the hull against any deformation due to lack of support on the keel in docking; but principally in order to insure their taking such a strain in docking that when the side supports were worked they would be ready at once to do their full work. The advantage of so doing was evident after docking, every timber setting taut with a good strain until they were ringing.

Care was taken to land the heads and heels of the timbers at the top or bottom of the fore and aft bulkheads, or at the heads and heels of stanchions.

After working the cradle shores above described the wedges under them were "vallied up" together fore and aft until the bow of the ship was lifted perceptibly off the blocks. While the keel and longitudinal supports were removed, an examination of the shores showed them to be doing full duty. Sight marks were established at the stem and two points at the sides, and a transit instrument was used in sighting across the dock over the top of the turret to discover any settling of the hull or sagging of the turret. But, although the usual settling throughout the ship's length was noticed for a few days after docking, after wedging up on the cradle there was no variation whatever at any stage of the work.

The vessel was docked in 2½ days from the time of hauling in; and the work of repairs to the bottom, now practically complete, occupied 83 days.

The work of repairs was carried on as follows:

The longitudinals and frames were repaired on each side abaft the turret first, while the most seriously injured parts, just at the knuckle forward of the turret, were cut away, the latter including practically all of the steel bottom plating, keel, frames, longitudinals, bulkheads, and inner bottom, from the poppets on one side to those on the other, for a length of 60 ft. in one stretch. Here the steel was so crushed and mangled that there was not the least opportunity of cutting out and replacing the work piecemeal. After finishing the longitudinals and frames abaft the turret, the vertical and flat keel plates were removed for a length of about 50 ft. and repairs made.

After the portions forward of the turret and abreast of it were finished, the keel under the turret was renewed.

The bottom was so crushed over more than half the length of the vessel that it was at once decided that the new work could not possibly be fitted without laying the vessel's lines down in the mold loft, which was done before docking; and aside from the necessities of the case, this assisted the work in other ways.

An idea of the extent of the steel work done in these repairs can be had from the following statement: The plating had to be removed over the entire flat of the bottom on the starboard side, and two-thirds of that amount on the port side, for more than half the ship's length.

72 new bottom plates were worked;
8 old plates were re-rolled and put back;
9 new outer keel plates were worked;
3 old outer keel plates were rolled and replaced;
7 new inner keel plates were worked;
3 old inner keel plates were rolled and replaced;
3 new vertical keel plates were worked;
2 old vertical keel plates were rolled and replaced;
16 new longitudinal plates were worked;
8 new inner bottom plates were worked;
6 old inner bottom plates were rolled and replaced;
11 bulkhead plates were renewed;
8 old bulkhead plates were replaced;
44 frames were cut out and renewed, starboard;
31 frames were cut out and renewed, port;
67 frame brackets were renewed;
30 floor plates were renewed;
20 watertight floor plates renewed.

In all there were 172 tons of steel cut out in these repairs and 128 tons renewed. An average force of 200 men were employed. Pneumatic tools were used for drilling out rivets, cutting out, chipping and calking, and driving rivets in non-watertight work. The sand blast was used for cleaning mill scale from the outside surface of the bottom plating, and was found to be very satisfactory. The plates, after being completely worked in the shop, were stopped at the sand blast on the way to the ship, without re-handling; and none of them required more than 15 minutes for the operation. Flaws, corrosions and cracks in old plates which apparently were in good condition, were discovered by this process in several instances.

The work of cementing and painting the double bottoms, testing the compartments and fitting new docking keels (not previously fitted to the vessel) is still under way, and it is expected at the time this is written (Feb. 10) that the "Oregon" will be removed from the dry-dock about March 1.

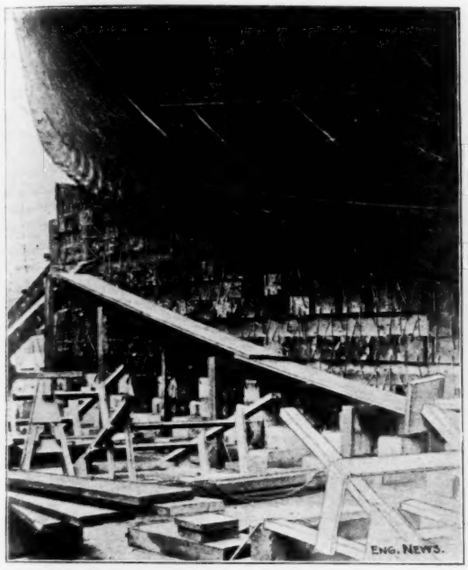

Fig. 3. Cribbing Under Port Bow of "Oregon."

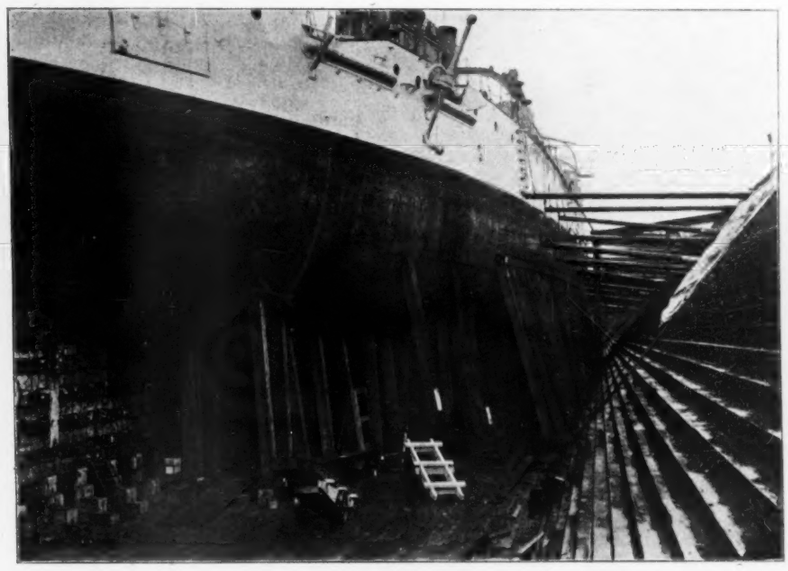

FIG. 4. VIEW OF SUPPORTS AT SIDES OF HULL.

A FEW NOTES ON THE USE OF THE PLANETABLE FOR RAPID STADIA WORK.

By John W. Hays,* M. Am. Soc. C. E.

In a practice of twenty years I have met but one engineer, outside of government circles, who made use of the planetable, and he had acquired his knowledge in the German army. There must be engineers who use this instrument, but evidently they are so few in number that it may be said that this most convenient device is unknown to the general practitioner. When I talk to engineer acquaintances about the planetable, I find they have a vague recollection of some such instrument in the classroom—a slow method requiring signal poles, flags, heliographs; very pretty, no doubt, if one had nothing else to do but play with it; but as a practical instrument for everyday work, an absurdity! On one occasion, after commending to a railroad engineer the planetable for preliminary lines, I heard him remark as I turned away, "Well, that shows how much he knows about railroading. A planetable!"

A planetable as originally made and used was a slow instrument, applied to high-class topography, where time and cost were secondary considerations. But in recent years there has been evolved a simple instrument and rapid method which may be applied effectively to almost every class of work which comes to the engineer in general practice. I have found the planetable effective for topography over densely-wooded country; for river surveys in connection with all the problems of power development, dam sites, reservoir areas and contents; for water-works surveys, with the incidental problems of drainage areas, storage basins, high reservoirs, pumping plants and distribution systems; in the design of sewerage systems, in railway and highway location, and even in land surveys. The desire that others may apply this instrument, which I have found of such general utility, prompts me to record these notes from my experience.

INSTRUMENT OUTFIT.—The instrument which I have found most useful is the "Johnson Movement," with a 21-in. board, and the telescopic alidade designed for the U. S. Geological Survey. This Johnson movement has no leveling screws, but is leveled and oriented by a ball and socket movement. The level used for the table is a small circular bubble fixed to the blade of the alidade. A 4-in. compass is inserted into the side of the board for purposes of orientation. A skilful instrument man will set up, orient and level his board with almost a single movement. It is done instantly. The telescopic alidade is provided with stadia wires and carries a striding level. The telescope is accurately leveled for each position on the board by means of a tangent screw. No refinement in leveling the board is necessary beyond that which will permit the needle to swing freely.

The rod which I use is shaped and marked in a somewhat peculiar way, and has been developed from repeated trials with many different rods. For quick and accurate use the rod must be sharply marked so that the eye will instantly read level and stadia distance. My rods are made 15 ft. long, 2 ins. wide at bottom and 1.25 ins. at top, cut out of inch stuff. Markings are all black on white body. The figures for even "feet" cover 0.2 in height and have a broad band across the "foot" line. The "tenth" markings are as large as possible, and have the figures "1" and "9" omitted. A rod marked in this manner permits the level and stadia to be read quickly and accurately at a distance of 1,200 ft. This distance, however, is rarely approached in practice, my limit being 600 ft. The tapering shape of the long rod makes it easy for the rodman to handle and carry and facilitates rapid work in woods and swamps.

Distances are scaled on paper by a white 6-in. scale, and it is desirable that the scale should carry no other graduation that that being used. Paragon paper, unmounted, is recommended. An umbrella is invariably a part of my outfit, chiefly to shade the white paper, but it otherwise greatly facilitates the work. This part of the outfit is frequently a source of much amusement to those who have never tried it, but I regard it as indispensable.

METHODS.—In detail work, such as the location of a dam site or the laying out of a park, or any similar work covering small areas, I use a scale of 100 ft. to 1 in., with contour intervals of 2 ft.; but on railway surveys, highways, large reservoir sites, sewerage systems, etc., a scale of 400 ft. to 1 in., with contour interval of 5 ft., is most effective.

The makeup of the field party is seven men to each planetable, as follows: Topographer, assistant, two rodmen, two axemen and a "pacer," or director of the party. The topographer is the instrument man, of course, and in moving from station to station carries only his alidade. The planetable is carried by his assistant, who also holds the umbrella at the station and records and computes levels. The level reading is first taken

*Petersburg, Va.

from the rod and by the time the topographer has platted the distance the assistant has determined the correct level, which is then written on the map and the contiguous contours sketched in.

The two rodmen are used alternately, the one moving into position while the other is engaged with the topographer.

The two axemen can usually keep the way open as fast as the topographer will advance. Sometimes one will be sufficient, and rarely a greater number may be required. It is poor economy to be short of axemen.

The "pacer," as I term him, leads the way, places the rodmen and directs the axemen, leaving the topographer to give his undivided attention to topography. With this arrangement and makeup, no man of the party is at any time waiting for somebody else; all are engaged all the time, and the work moves swiftly, as by its own momentum. I have experimented with all combinations in party makeup, from two men to nine, and find the best efficiency from the seven above named.

When working in the average country of the South, say half open land and half thicket and forest, and with a rolling relief of about 100 ft., this party of seven, in one working day of eight hours, will cover four lineal miles with an average width of 600 ft; that is, 300 ft. on each side of the line. This is determining every salient point to "tenths," and having no contour misplaced to an extent which would invalidate the map for the purposes intended. Only the salient points are determined by actual rod reading, the intermediate contours being sketched in.

An expert instrument man will make ten stations to the hour, and will average a half-mile to each hour's work, or four miles to the working day of eight hours. This indicates 264 ft. as the average distance of stations. Under exceptional conditions I have known topographers to make 100 stations and cover five miles in about eight hours. This was an instrumental station for every five minutes in the day, and was truly expert work, and possible only after months of training with every man in the outfit working like clockwork. This was in average farming lands, half open and half covered. In thick rough work, as in uncultivated river bottoms, the lineal distance will be reduced to about 2½ miles and the width of work to 100 ft. on each side of line. The areas covered in one day's work, when the work is massed and not strung out, will vary from one mile square to half a mile square, as the character of country varies from open and rolling to thick and rough.

COST.—Each planetable party of seven good men will cost in the South about $12 per day. It may be of interest to give the exact items of this sum, which I take from my last season's work:

Expense of one planetable party (seven men), one month:

Topographer	$50.00	
Assistant	20.00	
2 rodmen at $20.00	40.00	
2 axemen at $15.00	30.00	
Pacer	50.00	
Payroll		$190.00
Rations, 7 men at $9.78	$68.46	
Livery	26.95	
Miscellaneous camp supplies	14.49	
		109.90
Total		$299.90
Cost per day's work, 25 days, approximately		$12.00

This figure, of $12 per day for each planetable party, includes everything except the chief engineer and camp servants. But this is sufficient for comparison with the method of transitman, levelman, topographer and draftsman, with all their helpers. The figures given for quantity of work per day and cost of party, indicate that areas cost from $12 to $48 per square mile, which does not include chief engineer and camp servants. We may safely estimate all classes of topography necessitated by ordinary railroad and river work at $50 per square mile, including everything, scale 400 ft. to 1 in., contour interval 5 ft.

The error in levels accumulating from a day's run of this rapid work will rarely exceed 1 ft., and frequently will fall within 0.3-ft., while error in position should not exceed 100 ft., or half of 1%. In work of great extent, or requiring greater accuracy, a control line is run, with transit and level, or level alone, and upon this the planetable work is built up with no appreciable error.

APPLICATION OF THE PLANETABLE STADIA METHOD.—As already stated, this method is applicable to nearly all the work which comes to the engineer in general practice. With a contoured map on the scale noted, a railroad line may be located to the best advantage, both as to alinement and grades. After the location is made on paper, it would need to be staked out in the usual manner; but this would be done with certain knowledge that the best route had been selected. This is especially true in rolling country, where the engineer, after running many trial lines, finally locates with the feeling that some better line has perhaps been overlooked. We will suppose two points, ten miles apart, to be definitely determined on the line of a proposed railway. The intervening country is in relief of about 100 ft. above the main drainage, and broken into rolling hills by the secondary streams. It is probable that an area of 20 sq. miles will embrace all possible routes between these two fixed points. With this area mapped before him, in the manner suggested, the engineer can select the route with certainty and frequently locate on paper, even to grades and curves. Such a map of 20 sq. miles will cost by the method indicated but $1,000, a mere bagatelle when compared with the results attained.

The method is also applicable to very difficult mountain work. It happened recently that a surveying party reached a certain low gap in the Blue Ridge, and were disappointed to find that the descent of the mountain within the limits of grade would necessitate a long and expensive tunnel which had not been contemplated. The writer had just made a contoured map of that particular locality, and reference to this indicated that a loop around and under a sharp peak, rising half-way down on the crest of a narrow spur, would permit a desirable location well within the limits of maximum grade. This location was at once adopted. The planetable map which saved that tunnel had cost but a few hundred dollars.

The engineers were a great while locating a possible line up the Blue Ridge in the approach to Asheville. Had a contoured map, which could have been made cheaply and quickly, been in their hands, the best possible route could have been selected in a few hours. Let me hasten to add that I am comparing instruments and not men.

In the preparation of plans for sewerage systems, the planetable and stadia will give a map of the district showing the respective drainage areas, the layout of pipe lines and all information desired except the specific quantities of earth to be handled in the trenches. Even this last item will be given sufficiently close for all purposes but the final settlement with contractor.

In all river work the planetable and stadia is absolutely indispensable, since nothing can take the place of these within reasonable limits of cost. The cost of determining accurately the areas and prospective contents of reservoir sites, miles in extent, will in many cases forbid the undertaking if it should be necessary to use the transit and level method. Think of determining the configuration of a reservoir site 25 miles along a river, varying in width from 100 yds. to a mile, with all its littoral irregularities and affluent streams, by means of transit and level. The cost would be often prohibitive. And yet with planetable and stadia this was lately done for $3,000. The area was 60 sq. miles, including secondary streams. Illustrations could be multiplied indefinitely, but enough has been given to indicate the wide range of application to work where this method is now little known.

The planetable is very exacting upon the attention of the topographer, and eight hours' work over the instrument is about the limit of endurance. It is all which should be required, but in those eight hours work may be pushed to the utmost limit, and I think it must be admitted that the results are economical.

In the first camping party of which the writer was a humble member, the men were turned out at daylight and worked until dark. They lived in dog tents or in no tents at all; bedding was a couple of blankets spread on the ground; table service, tin; table, an upturned box; chairs, unknown. The men went uncombed and unshaven, wore great pistols and swore tremendous oaths, and everybody was overworked, mad and ill of all manner of cussedness. In twenty years of tenting I have come to believe that the best results are to be gotten from a well-equipped camp, regular reasonable hours and good feed. I use comfortable tents with oiled canvas on the ground, white linen and good ware on the table, chairs and suitable bedding, and absolute cleanliness in every respect possible. The observance of the decencies and amenities of life are as desirable in camp as elsewhere, and the effect of such observance is seen in the contentment, the tone and the increased efficiency of the party.

In work of every description where a map may be used, particularly a relief map, the planetable and stadia method is unexcelled for speed, economy, and general effectiveness. If good engineering lies in accomplishing desired results with the least expenditure, then this is a method worthy the attention of all who have not yet made its acquaintance.

A 30-TON STEEL DERRICK CAR FOR BRIDGE ERECTION.

For erecting heavy girder work, the Structural Department of the Illinois Steel Co., Mr. W. H. Pratt, Manager, has recently built the 30-ton steel derrick-car herewith illustrated for Mr. L. M. Bernhisel, Evanston, Ill., who is a contractor for the erection of railway bridges and other heavy steel structures.

The car-body is made entirely of steel; with two heavy side-girders, 32 ins. deep and 10 ft. apart, with 9-in. channel cross-beams spaced 2 ft. 6 ins. c. to c. and covered with 5-16 in. floor plates. The carrying capacity of the car is 100,000 lbs.; and it was designed to resist the stresses produced by the loaded derrick as well as those resulting from the regular loads carried. The trucks and wheels are extra heavy, as with a full load on the derrick the forward truck carries a total weight of 70 tons. The car is provided with screw-jacks at the sides which can be lowered to a bearing to give greater stability in lifting ordinary loads.

Clamps are also fastened to each end of the car, which may be secured to the track-rails when heavy loads are being handled. Underneath the rear end of the car is a steel box carrying 4 tons of counterweight. The car is self-propelling through a chain driving wheel connected with one of the rear axles and operated by the engine on the car. Under the center of the car-floor is a 2-in. plank tool-box, 10 ft. square, in which tools, rope, etc., are stored in transportation. To permit access to this box, there are two small doors through the web-plates of each of the steel side girders.

Power is furnished by a 30-HP. Lidgerwood hoisting engine, with link motion. By means of a clutch and train of gears this engine can move the car in either direction at a maximum speed of about 8 miles per hour. The engine is placed as far to the rear as possible, only leaving room behind it for two galvanized iron water tanks, 3 ft. diameter and 7 ft. high, and a small space between the tanks for coal. The entire engine and operating machinery is covered with a small wooden house, arranged to open on the sides and front when working. Two side wooden platforms on brackets, are detached when moving.

The derrick is built entirely of steel. It consists of a 24 ft. mast and an A-frame with a 40 ft. boom, for lifting 30-ton loads. The A-frame is fastened to the car on each side of the forward truck by two pins on a side; by removing the forward pins the frame and mast can be swung back and down to rest on supports on the car floor. The bottom end of the mast is pivoted to a bronze-bushed socket, bolted solidly to the floor and underframing. The lower end of the boom is connected with the mast by a 4-in. pin, which may be removed and the boom hauled back on the floor of the car, ready for transportation, as shown in Fig. 2. The boom has a 20-ft. extension piece; but when this is added the derrick is only used for loads not exceeding 18 tons.

The top of the A-frame is provided with guy-

rigs, from which ropes can be led when heavy loads are to be handled at the side of the track. The main sheaves are 20 ins. diameter, grooved for three 1-in. wire ropes. Each block contains four sheaves, two of these only being used for ordinary work. The wire ropes are carried directly from the engine-drum to the boom, over small sheaves, or drums, at the top of the mast, and between two guide wheels at the sides of the mast. This arrangement keeps the lines off the

FIG. 1. 30-TON STEEL DERRICK-CAR WITH 40-FT. BOOM FOR BRIDGE ERECTION WORK.
Built by the Illinois Steel Co. for L. M. Bernhisel, Contractor, Evanston, Ill.

car and avoids any sharp changes in direction of the rope until the main sheave wheels on the boom are reached.

This car and derrick were tested on Jan. 24. It was required to lift 30 tons with the 40 ft. boom inclined at an angle of 40° with the horizontal; and to swing this load between points 10 ft. each side of the center line of the track. For the load, ten 24-in. 100-lb. beams were used, each beam 60 ft. 2 ins. long. The weight of the car and engine about balanced this load, the clamps at the rear taking little or no load. The test was eminently satisfactory. With the aid of this car 70 ft., 80 ft. and even larger girders can be carried forward and set in position in front of the car.

The general design of the car was made by Mr. Oliver J. Westcott, in charge of the estimating department of the Illinois Steel Co., and the detail drawings were made under the supervision of Mr. E. K. Scott, in charge of the drafting-room. The car is to be at once put into use by Mr. Bernhisel on heavy girder and bridge work for the Chicago & Northwestern and a steel viaduct at Omaha, for which he has the erection contract.

NEW CONSTRUCTION WORK ON THE PENNSYLVANIA R. R.

The annual report of the Board of Directors of the Pennsylvania R. R. Co. to the stockholders, made public on March 4, gives some interesting particulars of the new construction work recently completed, in progress or projected on the system. We reprint a portion as follows:

A further issue of your capital stock was made for the purpose of acquiring the stock of the Philadelphia, Wilmington & Baltimore R. R. Co., not owned by your company. This road and the Baltimore & Potomac will be hereafter merged into one organization. This is the more essential, as large expenditures will be required in connection with the revision of your line and the elimination of grade crossings in the National Capital, the erection of a new passenger station at that point, and the renewal of the bridge over the Potomac River.

A very large amount of work upon the main line and branches and on the United Railroads of New Jersey is included in the extraordinary expenditures for the year. The improvements at West Philadelphia cover a change of alinement between Powelton Ave. and Market St., the erection of a station at that point for the interchange of passenger traffic between the main line, the United Railroads of New Jersey and the Philadelphia, Wilmington & Baltimore R. R., and the elimination of the existing grade crossings of freight tracks by the main line passenger tracks and those of the Schuylkill Division. This work is being vigorously prosecuted, and will be completed during the coming summer.

The pneumatic automatic signals were completed to Paoli, the revision of the line and the construction of the four-track system completed at Rheems, on the Philadelphia Division, and the under-grade crossing at Market St. partially constructed under the agreement with the municipal authorities of Harrisburg.

On the Middle Division the masonry of the new bridge over the Susquehanna River was completed, the line revised at Marysville so as to carry your passenger tracks over the Northern Central Ry. and yards, and a large amount of work done in revising the line and extending your four-track system between Duncannon and Aqueduct, Lewistown and Mifflin, and between Mount Union and Mill Creek. The third track was also extended from Spruce Creek to Union Furnace.

On the Pittsburg Division an exceptionally large expenditure was made on the four-track system between Wilmore and Summerhill, Latrobe and Beattys, Larimer and Stewart and Stewart and Pitcairn.

At Pittsburg the waiting-room of the new passenger station has been in use since October 1, and the reconstruction of your terminals at that point is being pushed to completion. This embraces not only the office building and the train shed and the elevation of your tracks in Pittsburg, but also the reconstruction of the Fort Wayne bridge over the Allegheny River and the elevation of the Western Pennsylvania & Fort Wayne tracks through Allegheny City. The most liberal expenditure will be necessary in the district of which Pittsburg is the center, to enable your company to handle promptly and effectively the heavy freight traffic originating and concentrating at that point, and this will be required not only on your main line, but on the Pittsburg, Virginia & Charleston and the Pittsburg, Cincinnati, Chicago & St. Louis Railways, on the south side.

On the United Railroads of New Jersey Division the Passaic branch of the New York Bay R. R. around

Fig. 2. 30-Ton Derrick-Car with A-Frame and Mast Stowed for Transportation.

Newark was finished, and the main line of that road constructed to the bay.

The elevation of your tracks through Newark and New Brunswick is being pushed forward and the new bridge at Trenton will be erected this year.

The bulkheads and piers at Greenville are in process of construction, to accommodate your traffic destined to and beyond Long Island and to points on New York Harbor.

Your pier facilities at Greenwich and Shackamaxon St., Philadelphia, have been improved and extended, and large purchases of real estate and right of way have been made at various points.

The extraordinary expenditure during the current year will be largely confined to the work now under way, covering the improvements on the passenger line between Broad St. Station, Philadelphia, and Overbrook, the completion of office building, train shed and other terminal improvements at Pittsburg, and the completion of the four-track system between Duncannon and Aqueduct, Lewistown Narrows and Mifflin, and Mount Union and Mill Creek on the Middle Division, and between Wilmore and Summerhill, Latrobe and Beattys, and Larimer and Stewart on the Pittsburg Division.

It will, however, also be necessary to improve the passenger station at Harrisburg, to construct a new single track tunnel at Gallitzin and hereafter rebuild the old tunnel, and to improve the Port Perry bridge and tunnel so as to accommodate the traffic passing to and from the Pittsburg, Virginia & Charleston Ry.

The elevation of the road through Newark, New Brunswick, and Trenton will require considerable outlay, as well as the extension of the New York Bay R. R. to Greenville and the construction of the necessary facilities at that point.

The piers at Jersey City used by steamers engaged in ocean traffic require renewal and improvement, and your piers at Philadelphia will need additional outlay.

It will be noted that the sum of $5,000,000 has been transferred to the Extraordinary Expenditure Fund, to be applied to these general purposes.

The board have long felt that your interests, as well as the convenience of the public, require the extension of your line into New York and the establishment of a centrally located passenger station in that city, through which the inconvenience and delays of the transfer by ferry will be avoided. Various methods of accomplishing this result have at different times been considered. The great cost of a bridge excluded that plan, unless all the railroad companies whose lines terminate on the west bank of the North River would join in the undertaking. Efforts were made to bring this about, and your board offered to co-operate with the other companies to that end, but the project failed to receive the necessary support. The alternative was the construction of a tunnel line, but the difficulties incident to the operation by steam of a tunnel, at the depth and with the gradients required by the topographical conditions, seemed to make that method almost, if not quite, impracticable. Meanwhile, however, the successful operation of a number of tunnels in different parts of the world by electric power, notably the perfect working of the Orleans Ry. Extension in Paris, indicated that a satisfactory solution of the problem might be found in the construction of a line, to be operated by electricity, under the North River to a terminal station in New York, and thence under the East River to a connection with the Long Island R. R.; the tunnels to be of such dimensions as to admit of the passage of your standard trains, and electric motors to furnish the power for the transfer of the trains through the tunnels.

This plan has a great advantage over the bridge, in that it provides a direct connection between your system west of the river and the Long Island R. R., and gives to that road the benefit of a terminal station in New York. Preliminary investigations having favored its adoption, it was thought best to proceed at once to acquire ground for a station upon the location selected. This has been done and the greater part of the necessary property purchased at a reasonable price. The importance and cost of this work, however, and the fact that novel engineering questions were involved, made it the duty of your board, before proceeding further, to have the plans for construction, and, in fact, the whole subject, thoroughly studied by competent engineers. For this purpose a commission was created consisting of five civil engineers eminent in their profession, namely: Col. Charles W. Raymond, United States Army, Chairman; Mr. Gustav Lindenthal; Mr. William H. Brown, Chief Engineer Pennsylvania R. R. Co.; Mr. Charles M. Jacobs, and Mr. Alfred Noble.

This commission will supervise the preparation of all plans, and will have general control of the undertaking. The two members last named will have direct charge of the work, which has been divided into two sections, the North River section having been assigned to Mr. Jacobs, and the East River section to Mr. Noble. The study of the project has already progressed far enough to establish its entire practicability. As soon as the problem of building a tunnel under the North River was seriously dealt with, its supposed difficulties largely disappeared, and the commission will have, in fact, a choice between several feasible plans. The cost of the work will be large, but your board are satisfied that the expenditure will be fully justified by the results obtained.

A JEFFERSON MEMORIAL AND INTERSTATE GOOD Roads Convention has been called, to meet at Charlottesville, Va., on April 2, 3 and 4. This meeting has for its object the construction of a 2½-mile road leading from Charlottesville to the home and tomb of Thomas Jefferson, at Monticello. The work is in the hands of a Memorial Road Association, of which Gen. Fitzhugh Lee is President, and aside from benefiting people desiring to visit Monticello, the road is to serve as an object lesson in road construction to the people of that section of Virginia. The enterprise has the encouragement of the Office of Public Road Inquiries of the U. S. Department of Agriculture, as well as that of the National Good Roads Association.

TIME LOCK TO PREVENT DEPAILMENTS AT INTERLOCKED GRADE CROSSINGS.

At many of the smaller grade crossings equipped with interlocking plants no locking is used, so that there is nothing to prevent the towerman from opening the derail in the face of an approaching train. Even if electric locking is used, its protection may be lost through the wrong use of the release, or the misapplied ingenuity of the operator in devising secret methods of his own for evading the restrictions of the locking.

To prevent such accidents electric locking has been applied to some extent. The electric lock affords the protection for which it is intended, but for certain reasons its use has not been very general. The first cost of electric locking, which is about $400 for a simple crossing, has not stood in the way of its general use; the maintenance expense, however, is a matter of more weight, as it sometimes costs more to maintain the electric locks than it does to maintain the interlocking plant. Of course, I am now referring to points more or less isolated, where a considerable portion of the repairman's time is spent in traveling. Quite recently I have been experimenting with a time locking device, which is now on the market, which

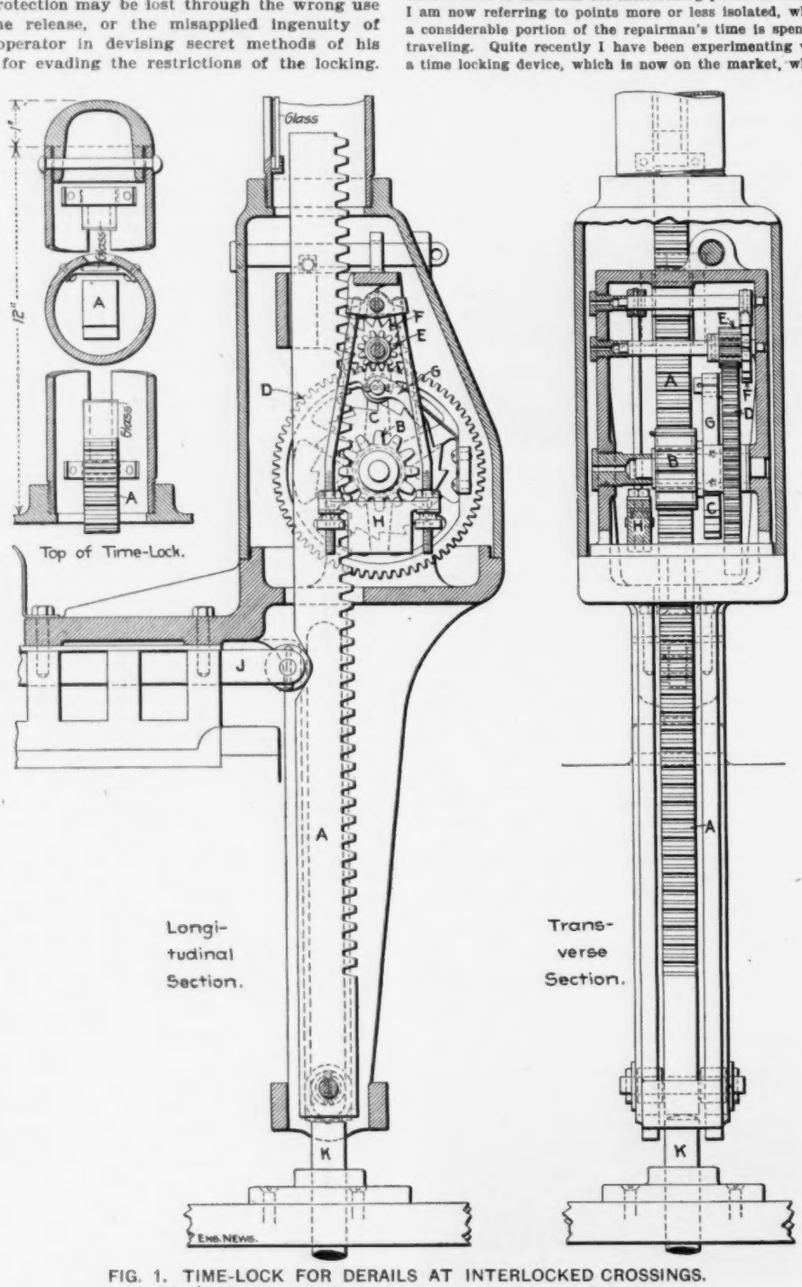

FIG. 1. TIME-LOCK FOR DERAILS AT INTERLOCKED CROSSINGS.
V. K. Spicer, Union Switch & Signal Co., Chicago, Inventor.

A positive time lock has been invented to provide against the derailment of trains against which the stop signal is suddenly displayed, whether rightly or wrongly, and the use of this device was described by Mr. Charles Dunham, Signal Engineer of the Illinois Central R. R., in a paper read at the meeting of the Railway Signaling Club in Chicago, on March 11. This paper was substantially as follows:

A number of derailments which have occurred recently at interlocking plants point to the necessity of providing appliances to prevent such occurrences. I have in mind several cases where a towerman took a home signal away from an approaching train after same had passed the distant signal, which had indicated "Proceed," opening the derail, with the result of a wreck of a more or less disastrous nature.

In a large measure fulfils the function of the electric lock. The time lock is applied to the home signal lever and connected with the locking of the machine in such a manner that after the home signal has been placed in the normal position a certain time limit must expire before the derail can be opened. The time limit may be made to cover a period anywhere between 15 seconds and 2¾ minutes. As a train ordinarily will not consume more than 30 seconds while running between the distant and the home signals, it will be seen that the time lock which requires a minute or perhaps less in which to run down would prevent any change in the combination immediately in front of an approaching train. The time lock is intended for use in connection with the ordinary mechanical machine, but cannot be used on a power machine. It can be set up complete at an expense of not to exceed $55 a lock. It is a very simple device, with nothing about it to get out of order, and should cost practically nothing for maintenance. My own experience has led me to believe it is more necessary to provide some locking device at small isolated crossings than at large, busy plan[illegible]

The mechanical time lock mentioned in Mr. Dunham's paper is shown in Fig. 1. The vertical rack bar A engages with the pinion B, which is [illegible] on one piece with the ratchet wheel C, both turning freely on the shaft as the rack bar is [illegible]. Keyed to the shaft is the spur wheel D, which in turn gears with the pinion E driving the escapement wheel F. To the spur wheel D is attached a pawl G, so that as the rack bar drops by its own weight it operates the spur wheel D by means of the pinion, ratchet wheel and pawl. From the shaft of the anchor escapement is suspended the pendulum H, the height of which can be raised or lowered by thumb screws on the ends of the pendulum rods so as to permit of adjusting the speed of the escapement in order to drop the bar within a given time. In practice, however, the time is mainly regulated by the position of attachment of the operating rod, as described below. The upper part of the bar moves in a cylindrical case, having a glass disk like an indicator, and the face of the bar is painted red, with a white top, so that the towerman or operator can see the portion of the bar. When the bar is dropped to its normal position, a cross dog J, operated by the derail lever, occupies the position shown, engaging with a notch in the face of the bar. When the bar is raised, the dog J is moved over to the left and locks the derail lever, which cannot then be moved to open the derail until the bar has fallen to its normal position.

The time lock is bolted to the back of the locking frame and the bar is raised by a lifting rod K, operated from the home signal lever by a connecting rod and bell crank. The stroke or lift of the bar can be of any desired height (to give any required time for its fall), the stroke varying with the point of attachment for the connecting rod to the signal tower, as shown in Fig. 2.

The time lock is not intended as a substitute for electric locking in all cases, but mainly for cases where the amount of traffic would not warrant the expense of installation and maintenance, and also by crossings on roads which have no signal department, whose employees are not as a rule competent to maintain and repair an electric locking plant. Many small interlocking plants have no locking appliance at all, and there is nothing to prevent a careless, sleepy or "rattled" towerman from displaying the stop signal and opening the derail right in the face of a train which he has given the right of way. With the time lock installed, at small expense, he could throw the home signal to "stop" at any time, but could not open the derail until a fixed time after displaying the "stop" signal, during which time a train at ordinary speed would have passed the crossing, while a train moving so slowly that it had not reached the derail within the time limit would probably be stopped before reaching it, or even if derailed would not be liable to cause or sustain much injury.

The device here shown is known as the mechanical time lock, but the bar may be a plunger in a pneumatic or hydraulic cylinder, the rate of fall being regulated by an admission valve for air or a by-pass valve for water. The time lock, including its various methods of operation above noted, is the invention of Mr. V. K. Spicer, Engineer and Western Agent of the Union Switch & Signal Co., 1535 Monadnock Block, Chicago. About a dozen of the time locks are now in use.

A REPORT ON THE VIBRATION FROM THE CENTRAL LONDON RY.

A good deal has been published concerning the troubles experienced in London along the line of the Central London Ry., or "tuppenny tube," since it has been in operation, through the jarring and vibration in certain buildings along the route. As most of our readers will remember the railway is carried in a pair of cast-iron lined tunnels, which were driven with a hydraulic shield and are for nearly the entire distance in the stiff London clay. The depth below the surface is from 40 to 100 ft.

In the operations of the City & South London

and Waterloo & City railways, which are also deep level tube lines, electrically operated, no trouble from vibration had been experienced; and it was a surprise to everyone when the opening of the Central London Ry. was followed by serious complaints from those occupying buildings at various points along the line of the road. So serious was the trouble that on Jan. 4, 1901, the Board of Trade appointed an expert commission to investigate the matter. This commission was made up of Lord Rayleigh, the noted physicist, Sir John Wolfe Barry and Prof. J. A. Ewing. Lord Rayleigh is an Honorary Member, Sir John a Past-President and Prof. Ewing a Member of the Institution of Civil Engineers. The report of this commission has recently been rendered and we reprint it substantially in full from "The Engineer" of Feb. 21:

The witnesses all deposed as to the annoyance caused by the vibration experienced by them, and they were of opinion that the shaking of which they complained was felt most severely when the trains first began to run in the morning, again between 5 p. m. and 8 p. m., and the last thing before the traffic stopped at night. This they attributed to the trains being more heavily loaded at such times (an opinion which was not supported by the scientific evidence subsequently obtained by the committee), and they were nearly unanimous in stating that at times exceptionally severe vibrations occurred for which no reason could be assigned.

The committee also had the benefit of interviews and communications with Sir Benjamin Baker, the engineer to the Central London Railway, who explained the structure of the line and the measures which the railway company were adopting with a view to finding a remedy for the inconvenience complained of, and they also heard the views of Sir Douglas Fox and Mr. W. R. Galbraith, engineers of experience in the construction of similar railways.

As a first step, the committee satisfied themselves by personal observation that vibration sufficient to cause serious annoyance is actually felt in many of the houses situated along the course of the railway. A very little experience further showed that the disturbances due to successive trains are very unequal. In order to ascertain whether the specially severe disturbances could be connected with particular trains, some elaborate observations were instituted in which ten or twelve observers—many of them pupils of Professor Ewing—were stationed in various houses, and recorded during the whole of one day the times of passage of the trains and the estimated intensity of the vibrations. A comparison of these records with records made at the stations by other observers of the precise times of starting and arrival of the various trains gave the means of answering the question proposed. The results, analyzed by Mr. A. Mallock, who was employed by us for the purpose of conducting the details of our investigation, showed (a) that it was a matter of chance whether a given train caused a slight or a severe vibration; (b) that trains causing a severe vibration in one house were as likely as not to cause only slight vibration in the others; (c) that different rooms in the same house were not similarly affected by the same train.

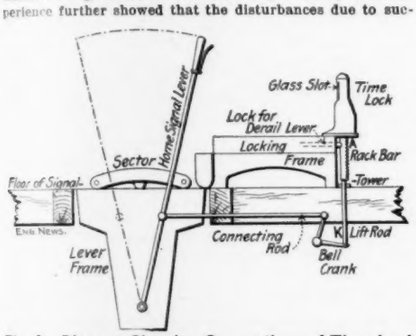

Fig. 2. Diagram Showing Connections of Time-Lock for Derail.

In addition, Mr. Mallock, who had previously, in connection with some observations on vibration caused by the running of an experimental electrical train on the joint lines of the Metropolitan and Metropolitan District Railway Companies in 1899, devised suitable instruments for the purpose, made on behalf of the committee a careful study of the nature and extent of the vibration both on the Central London Railway and in adjoining premises, and for the sake of comparison made similar observations on the Waterloo and City Railway, the Metropolitan Railway, and a portion of the Great Western Railway where bridge rails similar to those used on the Central London Railway are laid down.

One of the most distinct indications from Mr. Mallock's records was the responsibility of the locomotives, as distinguished from the carriages, for the worst part of the disturbances, and the attention of the committee was called at an early stage to the excessively large load, unrelieved by springs, carried on each axle of the locomotives. The unspring-borne load carried on each of the four axles of the locomotive is 8 tons, making 32 tons in all. This construction was adopted in order to obviate the necessity for gearing, and the committee could not but connect the difficulty with the magnitude of this unspring-borne load. This view was in entire accordance with the results of the experiments on the Metropolitan and Metropolitan District Railways.

In the memorandum prepared for the use of the joint committee of Parliament on underground railways, at the request of the late Sir Courtenay Boyle, and given in evidence by him before that body on May 10, 1901, this committee were able to say, "that the observations so far made led them to the conclusion that the vibration complained of arose chiefly from two circumstances, viz.: (1) The large proportion of the weight of the locomotives not borne by springs, and (2) want of rigidity in the rail."

The railway company had already ordered two new types of locomotives in which the unspring-borne load would be reduced, and in this direction there was nothing to be done but to await the arrival and trial of the new types.

The committee were also anxious to examine the effect of a stiffer rail on the Central London Railway itself. But although a short length would have sufficed, and the company did all that was in their power, the experiment could not be carried out. The present rail is of the "bridge" pattern, and room could not be found for the greater depth necessary to attain increased stiffness without encroaching too much upon the already narrow margin allowed between the tunnels and the tops of carriages. In the opinion of the committee it is unfortunate that so small a margin was provided. According to Mr. Mallock's observations of the air pressure in front of the trains, the power required to propel them is much increased by the closeness of the fit, so that there would have been compensation in this direction for some increased cost in constructing larger tunnels.

As to the cause of the vibration, the problem here differs materially from one with which it is sometimes confused, i. e., the explanation of the tremors propagated from fast running and imperfectly balanced machinery. In the present case there are no reciprocating parts, and the revolving parts are perfectly balanced. Moreover, the weight borne on the axles of the locomotives, even though unrelieved by springs, will not of itself account for the objectionable vibration. If the tires were perfectly circular, and the rails in their natural condition were perfectly straight, and were so supported as to yield everywhere equally to the load as it passed, there would be nothing to cause vibration. When rails are supported on transverse sleepers, vibrations corresponding to the distance between the sleepers are to be expected, and may in some cases be traced; but on the Central London Railway the sleepers are longitudinal. It was thought at first that the rail joints, which must almost inevitably introduce a varying yield, and which do, in fact, cause a good deal of noise, would prove to be an important source of vibration, but Mr. Mallock's records do not bear out this anticipation. Another want of uniformity of support, probably operative to some extent, is due to the flanges by which the lengths of tube are connected. Where the sleeper crosses the flanges, the yielding under load is presumably less than at intermediate places.

From measurements made by Mr. Mallock there is reason to believe that the principal source of disturbance lies in the unevenness of the surface of the rails. As they leave the rolls the rails are usually curved, and the process of straightening by local bending beyond the elastic limit, however skilfully carried out, inevitably leaves a certain waviness. As the unspring-borne part of the load follows the rail over the crests and hollows of the waves, it is subject to vertical accelerations which cause the pressure on the support to become variable. When there are no springs, and the speed is high, a state of things is soon reached in which the pressure on the rail momentarily disappears and the load is on the point of jumping across the hollows. Such part of the load as is carried by suitable springs moves nearly in a horizontal line without following the waviness of the rails, and the pressure on the rails corresponding to it remains nearly uniform and accordingly innocuous. When very high speeds are contemplated it may become a question whether a higher standard in respect of straightness should not be aimed at.

It appears that the irregular impulses given by uneven rail surfaces have the effect of establishing and maintaining an oscillation of the rails and road bed, the whole being regarded as an elastic support loaded with those masses which are not carried by springs. This view is borne out by the observed fact that the chief oscillations, as recorded in the tunnels, were found to have about the same frequency when the train producing them was run at various speeds.

The new locomotives were ready for trial in August, and were of two types. In one the locomotive is, as before, distinct from the passenger cars, but gearing is introduced, so that the electric machinery is no longer mounted directly upon the driving axles. The unspring-borne load is correspondingly reduced, and amounts to 2½ tons on each axle, as against 8 tons on each axle of the old locomotives. This type, of which there are three specimens, is described as the "geared" locomotive.

In the other system, known as the "multiple unit," or motor-car system, the locomotive is not distinct, but motors are carried at one end of two or more passenger cars. In this case the unspring-borne load on each axle of the truck under the motor is 1¾ tons. Some further particulars are set out in the following table:

Weights per Axle on the Various Classes of Rolling Stock Referred to in the Report.

Description of rolling stock.	Weight per axle in tons. Spring-borne.	Unspring-borne.	Total.
Gearless locomotive (total weight, 44 tons)	3	8	11
Geared locomotive (total weight, 33 tons)	5.75	2.5	8.25
Multiple-unit train (total weight of motor carriage, 20 tons):			
Motor axles	4.75	1.75	6.5
Other axles	2.4	1.1	3.5
Passenger coaches (total weight, 14 tons)	2.4	1.1	3.5

Observations in the tunnels made by Mr. Mallock for the committee showed, as had been expected, a great improvement. The vibrations in the ground decreased in proportion to the unspring-borne load; for the geared locomotive they were less than one-third, and for the motor-car train less than one-fifth, of what were caused by the ordinary locomotives. Like results were observed in some houses which we had previously visited.

We were naturally desirous of making personal comparison of the disturbances due to the various types. In order to identify the trains, it is almost a necessity to connect by telephone the house in which observers are placed with the signal-boxes at the neighboring stations. Signals can thus be sent at the moment when a train begins to move, and after an interval, which is nearly the same for trains traveling in the same direction, any disturbance caused by the train in question will be due at the house. We are indebted to Mr. Hoghton, of 13 Hyde Park Terrace, and to Mr. Pike, of 4a Marlborough Gate, for allowing telephones to be fitted in their houses, and for giving the committee opportunities for meeting there to make the necessary observations.

The first observations of this kind were made at Mr. Hoghton's house on November 28th. During some two hours every train either way drawn by an ordinary locomotive—gearless—was distinctly felt, while of the trains drawn by geared locomotives or by motor carriages not one was felt. This result was eminently satisfactory so far as it went; but we were desirous if possible of distinguishing the effects of the two new types, and it was for this purpose that further observations were made at Mr. Pike's house, where former experience had shown the disturbances to be very intense. The difference between the old and the new types was maintained, but it became possible to discriminate to some extent between the two new types. The passages of the geared locomotives were felt slightly in several cases, but in no case was the motor car train perceived.

In view of these results we have no hesitation in recommending the adoption of a type of locomotive or motor in which the load not carried on springs is reduced as far as possible. This may be arrived at by using gearing as in the geared locomotive or motor carriages, or by using a gearless locomotive, in which an elastic connection is employed between the driving-axle and the motor; but we have had no opportunity of experimenting with a locomotive of this type.

In the trials which have been carried out the motor cars were found to have an advantage in freedom from vibration over the geared locomotive. So far as the Central London Railway is concerned, we are confident that by adopting motor cars in place of the original locomotives the vibration produced by the running of trains can be reduced so as to cause no serious annoyance, although it is possible that the sound of the trains may still be detected, especially in the night. We are able to speak positively as to the motor cars; but we have little doubt that any method of driving in which the unspring-borne load on each axle is reduced to a similarly small quantity might also be used with impunity.

On the question of the best form of rail and sleeper we have no decisive evidence. We are disposed to prefer a stiffer rail than that in use on the Central London Railway, and we think that in new undertakings sufficient room should be allowed for the introduction of a deeper rail; but we are of opinion that, without altering the permanent way of the Central London Railway, the change of motors which we have recommended will effect a practically complete cure of the disturbances complained of.

ALTERNATIVE BIDS FOR A 60-IN. PIPE LINE some six miles in length are wanted on March 20 by the Street and Water Commissioners of Newark, N. J. The steel pipe, if used, will range from 5-16 to 7-16-in. in thickness and the cast-iron pipe from 1.5 to 2.1 ins. The pipe line will connect the Cedar Grove Reservoir, now under construction, with the city of Newark. Mr. Morris R. Sherrerd, M. Am. Soc. C. E., is Engineer and Superintendent of the Department of Water.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

Some interesting statistics of the deaths and injuries by lightning in the United States have recently been made public by the U. S. Weather Bureau. According to these statistics, the total number of persons killed by lightning in the United States in 1900 was 713, while 973 were injured. Most people are accustomed to think of death by a lightning stroke as a very remote source of danger, and of death by railway accident as a danger much to be feared. If we turn to the statistics of the Interstate Commerce Commission, however, we find that in the whole United States only 250 passengers were killed in railway accidents in 1900, or little more than a third as many persons as met death by lightning in the same year.

Is there really a place for the "moving sidewalk" as a means of passenger transportation? Commissioner Lindenthal apparently thinks there is, for he has recently proposed that such sidewalks should be installed to carry passengers across each of the three East River bridges. He proposes four lines of platforms running at speeds of 2½, 5, 7½ and 10 miles per hour, respectively. Only the 10-mile platform would cross the bridge, the others making a loop at the terminals, and being operated merely to enable a passenger to get on and off the 10-mile platform, which would be provided with seats like the one operated on the pier at the Chicago Exposition.

The attractive feature of the moving sidewalk for the Brooklyn Bridge is, of course, its enormous carrying capacity. We are inclined to think, however, that a more exhaustive investigation of the device than has ever been made should precede its adoption for so important a traffic route as the Brooklyn Bridge. It is true that the device (with two speeds only, and those quite moderate) was successfully operated at the Chicago, Berlin and Paris Expositions. Whether it would prove equally reliable and satisfactory at higher speeds is a matter which would need inquiry. A defect of the system is that any breakdown at any point on the entire circuit puts the whole line out of service, and there is no such thing as switching the disabled section out of line and putting a new one in its place, as is the practice with ordinary cars or trains. Of course by operating only during the rush hours and giving careful inspection and repair, breakdowns could probably be rendered very few; but the extent to which they are likely to occur should be carefully examined.

Again, the operation of such a system, even if it worked satisfactorily, would have a tendency to transfer the present crush from the New York end of the bridge to the Brooklyn end. It is true there is much more room there to handle cars and passengers than at the New York end; but, as we have frequently pointed out, the trouble with the Brooklyn bridge terminal is that it *is* a terminal and that the cars which cross it leave and take their entire load of passengers at one point instead of distributing them at a dozen different points.

The plan of the Board of Experts for improving the Brooklyn bridge terminals (Eng. News, Oct. 17, 1901) is now declared by Corporation Counsel Rives to be illegal. The law enacted to permit improvement of the bridge terminal was entitled:

> An Act to relieve the congestion and facilitate the traffic on the New York and Brooklyn Bridge, and to improve and extend the footways, roadways, railway tracks and other facilities for the use of pedestrians, vehicles and railway passengers at the westerly or Manhattan terminal.

The New York constitution requires that no local bill shall embrace more than one subject and that shall be expressed in the title. Mr. Rives thinks that the engineers' plans for elevated railway lines up Center St. and down Park Row cannot be considered "extensions." He says:

> The plan suggested by them not only provides for changes at the Manhattan terminal of the bridge, but also for the construction of two railroads, which are in no sense an "extension" of the Manhattan terminal of the New York and Brooklyn Bridge. It is simply a street railroad connecting the bridge with two other bridges
> If the act authorized such a construction as this it would be unconstitutional; but, as I have said, I do not think the act, while broad in its terms, confers any such right. Nothing can be done under it which is not an "extension" of the bridge or an improvement of its terminal facilities. I have to advise you, therefore, that the plan of the engineers, so far as it recommends the construction of the railroad, cannot legally be carried out.

We take the liberty of doubting whether the courts, if properly instructed by expert evidence, would coincide with Mr. Rives' opinion. Whether a structure is actually a street railway or an extension of a bridge terminal would depend largely on the purpose for which it was planned and built. The very fact that a board of expert engineers of undoubted ability planned a structure for the sole purpose of improving a bridge terminal would seem to be the strongest sort of evidence to define its character.

Brooklyn residents appear to have awakened to the fact that the expert plan is the best solution of the bridge terminal problem thus far presented, and a strong movement to secure its adoption is said to be under way. Whether they can overcome the opposition of the press and the public officials of Manhattan remains to be seen.

Another chapter has been added to the record of the Savannah Harbor frauds and the attempt to bring those responsible for them to justice. We gave a chronology of this remarkable case in our issue of April 12, 1900. It was nearly three years from the time charges were first brought against the engineer, Carter, until he was landed in the penitentiary. The contractors who conspired with him were indicted on Dec. 8, 1900, and since that date their attorneys have imitated the tactics of those employed by Carter, and have employed every possible legal technicality to delay the course of justice, including even appeals to the United States Supreme Court. Finally, when every possible subterfuge had been exhausted, on Jan. 20 last the indicted parties were forced to surrender themselves and give bail for their appearance for trial in Savannah at the February term of the U. S. Circuit Court. When the case was called, however, on Feb. 11, their attorneys interposed a demurrer to the indictment on technical grounds, which gave another brief delay. The decision on the demurrer was rendered on Feb. 24, and quashed two counts of the indictment while sustaining eight counts. An amended indictment was returned by the Federal Grand Jury on Feb. 28, and the trial was set for March 7. On that date, however, John F. Gay and Benjamin D. Greene, the two principal members of the contracting firm, failed to appear and Judge Spear ordered their bonds of $40,000 each forfeited and warrants issued for their arrest. He also took occasion to condemn the manner in which the defendants had treated the indictment against them, and declared that they had been trifling with justice. Press reports state that the fugitives are in Canada, and also that the two partners had intended to stand trial, but learned in some way that Carter had at last concluded to do what he ought to have done long ago—make a clean breast of the affair and become a witness for the government.

SHOULD EXECUTIVE OFFICERS BE HELD CRIMINALLY RESPONSIBLE FOR ACCIDENTS?

The Grand Jury which investigated the Park Ave. tunnel collision of Jan. 8, in New York city, indicted the engine-runner who drove his locomotive into the rear of a standing train, and failed to indict the railway company or any of its officials. As a result the jury and the District Attorney have been subjected to severe criticism. Public opinion, as represented in the newspaper press, has been practically unanimous in its condemnation of the company and its managers, and in absolving from blame the engine-runner, whose failure to obey a signal hidden in the smoke was the immediate cause of the disaster. "A Failure of Justice" and "a Parody of Justice" are the headlines under which such conservative and respectable journals as the "Post" and the "Times" comment upon the Grand Jury's action. It is natural for the public and for the journals which reflect public sentiment to take this view of the matter, undeniably. Here are seventeen people brought to a sudden and horrible death, while twice as many more suffer painful maiming and injury. The accident occurs, not through any catastrophe of nature—any act of God, as the law puts it—but through the failure of the operating organization of a great railway system. "Manifestly," says the public, "some one ought to be held responsible."

Well, the public is right—to a certain extent. In the present case the railway company will without doubt be held responsible for the payment of damages for each person killed or injured in the accident. This is not only justice to the victims of the accident and their friends, it is good public policy, since it tends to make railway companies careful to provide for the safety of their passengers.

But now the public goes further, and declares that such slaughter is a crime, and that the responsibility for the crime should be brought home to some one, so that he shall receive due punishment. It is worth while to seriously examine into this view of the case, inasmuch as it is the view very commonly taken. It is of far larger interest to our readers, moreover, than the particular accident which we have taken for our illustration. The engineer is very often placed in a position where human lives may depend on the manner in which he discharges his duties. Should he be made to answer to a criminal charge in case his precautions fail and lives are lost? Will the public be the gainer by holding him to such an accountability?

Before we can fairly answer this question it will be well to stop and consider the real purpose and object of the punishment of crime in an enlightened community. The crude idea, still too commonly held, is that the criminal law represents a sort of legalized revenge, by which society "gets even" with the felon for his attack upon property or person. But no warrant is found in either statutes or court decisions for such a conception. Society punishes the criminal first to deter others from committing a like crime, and

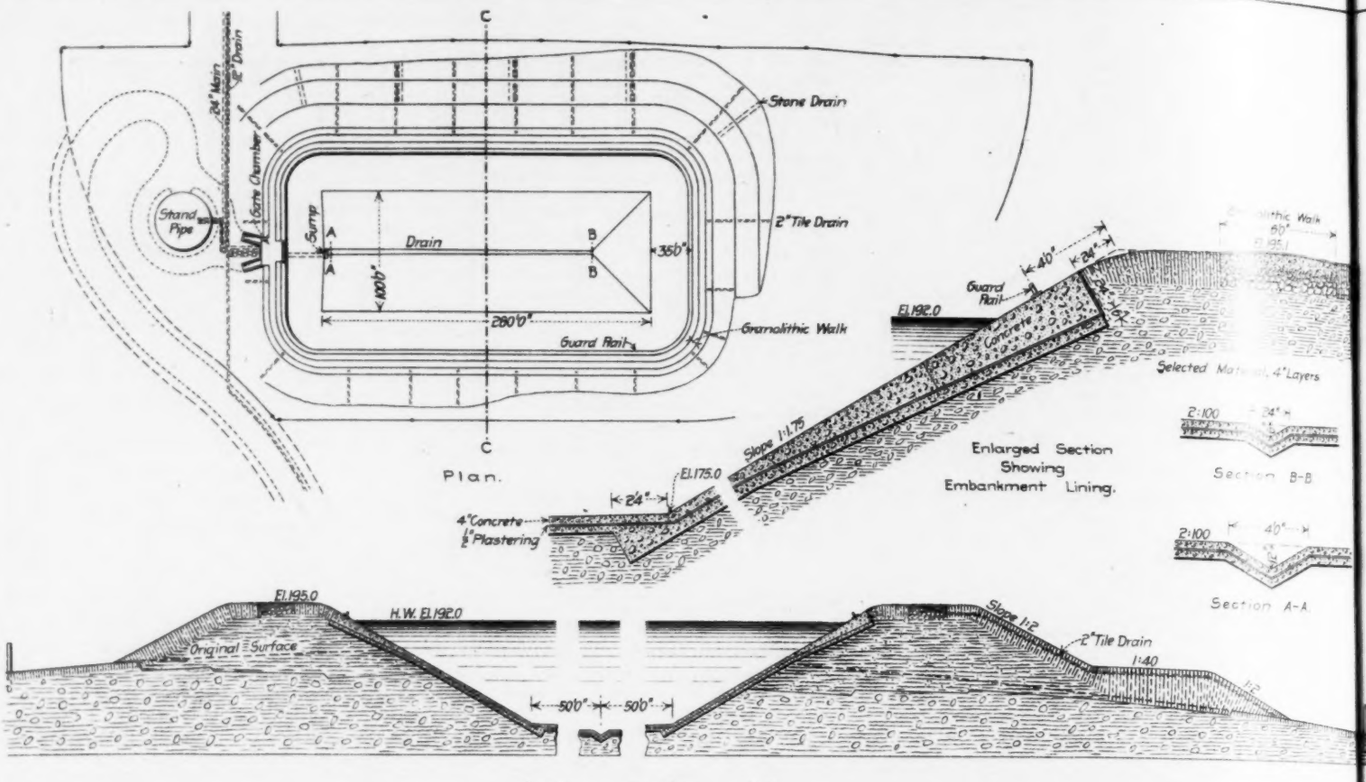


FIG. 1. PLAN OF RESERVOIR AND STAND-PIPE AND SECTIONS OF RESERVOIR.

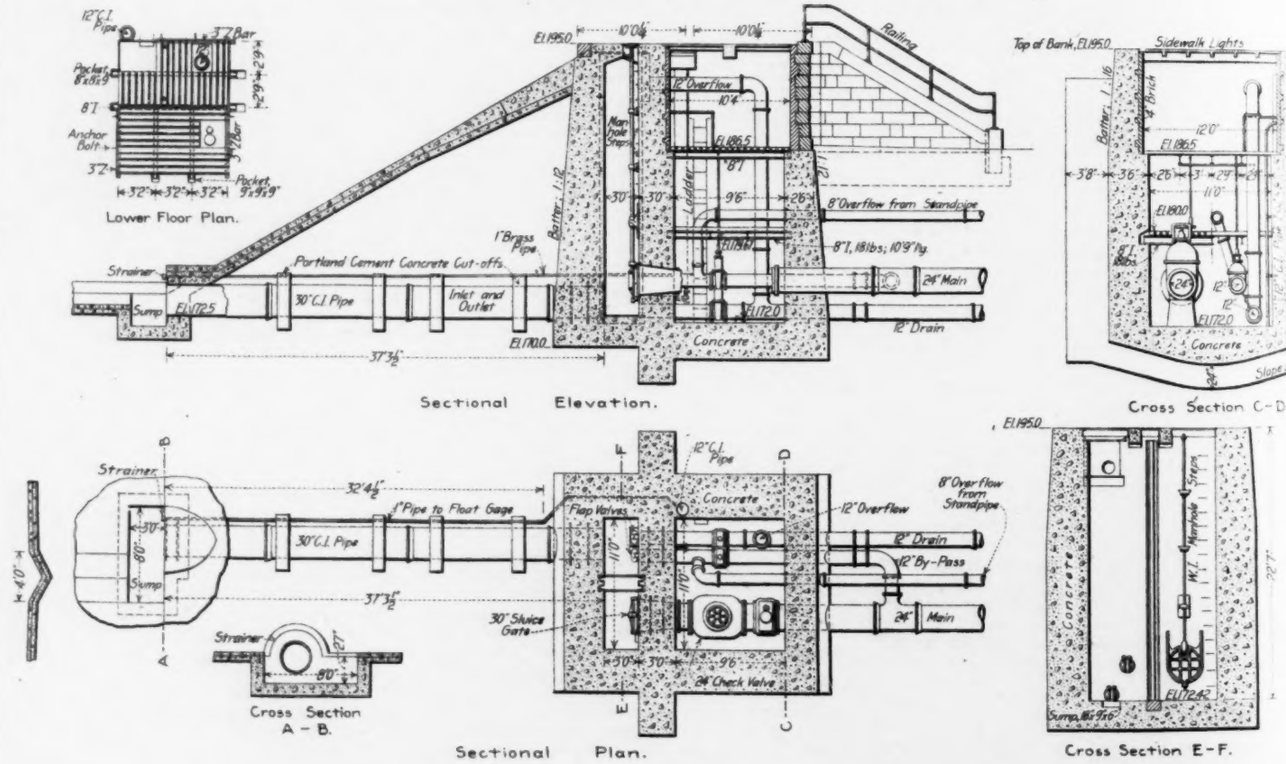


FIG 3. DETAILS OF GATE CHAMBER AND PIPE CONNECTIONS.

FORBES HILL RESERVOIR AND STAND-PIPE, METROPOLITAN W

F. P. Stearns, M. Am. Soc. C. E., Chief Engineer Metropolitan Water and Sewerage Board;

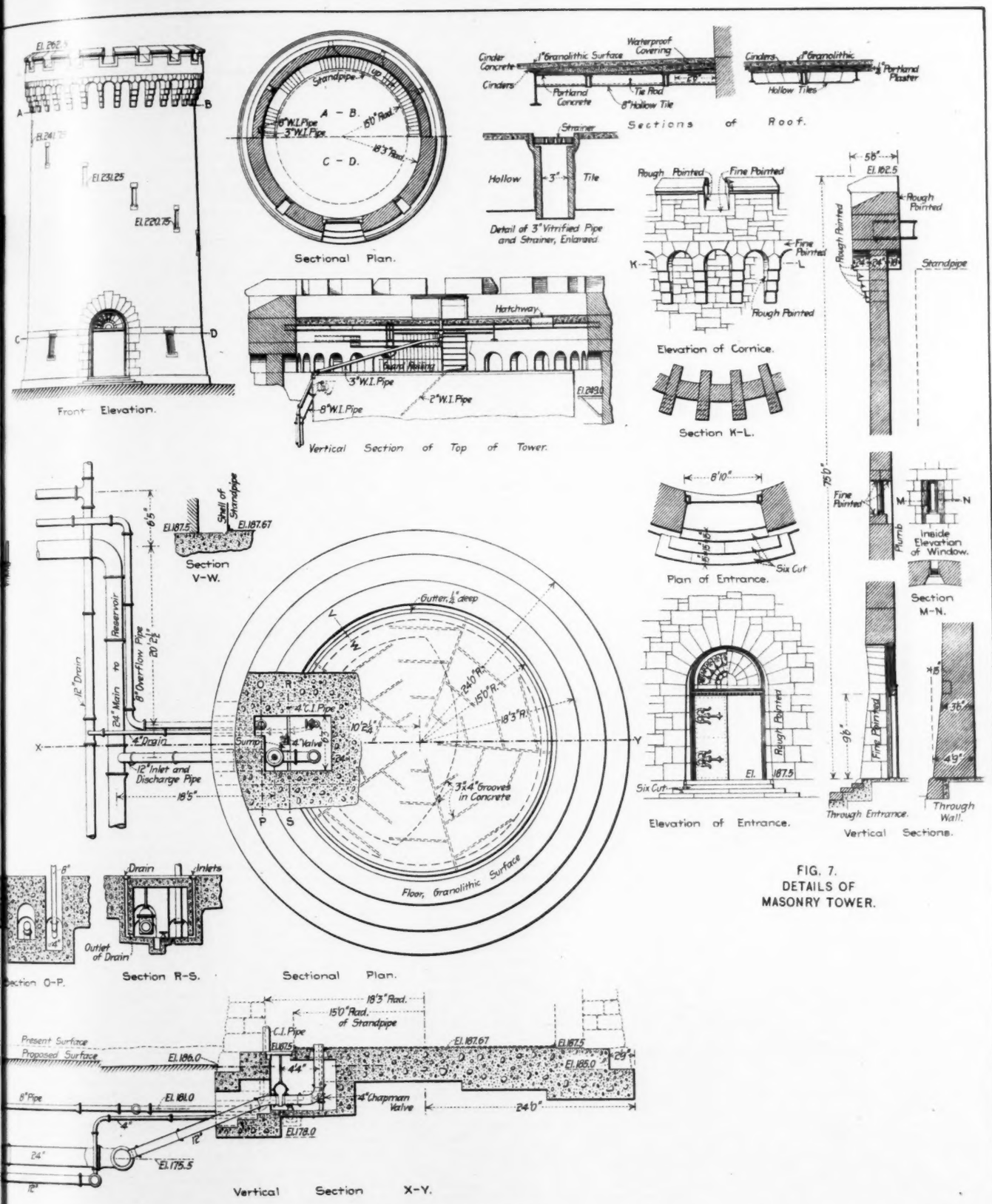


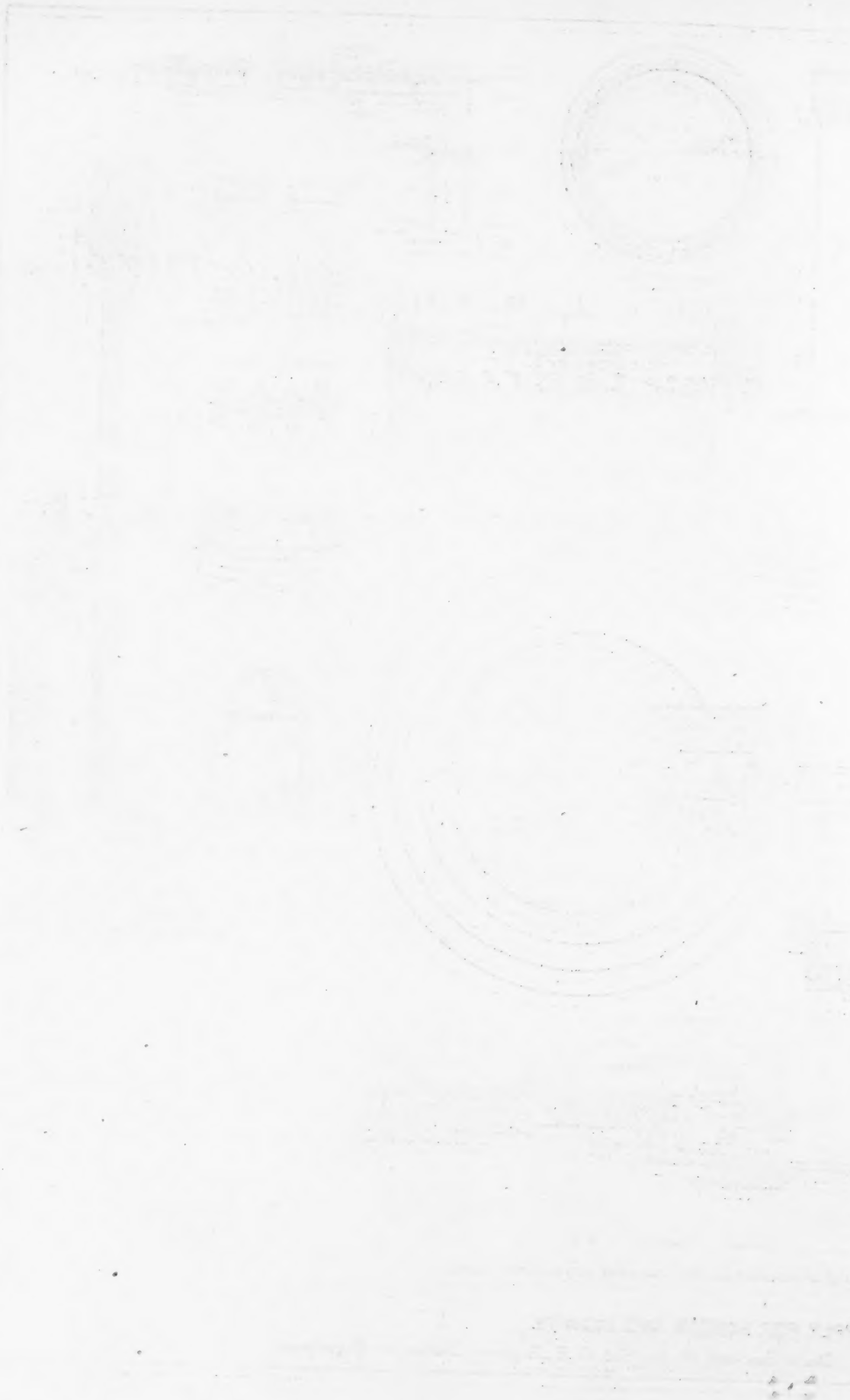
FIG. 7.
DETAILS OF
MASONRY TOWER.

FIG. 4. DETAILS OF FOUNDATION FOR STAND-PIPE AND MASONRY TOWER.

ETROPOLITAN WATER SUPPLY FOR BOSTON AND VICINITY.

Dexter Brackett, M. Am. Soc. C. E., Engineer Distribution Department.

CHAS. HART, LITH., 39 VESEY ST., N. Y.



second, under the most advanced systems of criminology, to restrain his criminal activity and train him to an honest and law-abiding life again.

How do these considerations apply to the engineer whose dam breaks or whose flywheel explodes; to the railway superintendent whose trains meet in a collision, or to the hotel proprietor whose guests suffer death by fire?

Clearly we shall not confine such men in a prison to reform them. If their responsibility for a disaster is a crime, it is one which they have committed unwittingly. No confinement in any reformatory could make a man of this class more anxious to do his duty faithfully and well, or better able to be a good and useful citizen.

The only reason, then, for punishing crime of the class we are considering is to deter others from committing a similar crime; and the real question, then, is whether in any given case such punishments will work for the public benefit in this way. There may be cases where gross and deliberate carelessness on the part of responsible officials where the safety of human life is concerned is such as to justify criminal prosecution; but as a general rule, it will seldom be found possible to so fix the responsibility that either the law or public opinion (when it reaches its sober second thought) will countenance a criminal charge.

It is a fact which should not be forgotten, that every accident of this sort is apt to bring its own severe punishment to all who share directly or remotely in the responsibility. Loss of position, injury to professional reputation, mental anxiety and torture—these are some of the penalties which are frequently brought home to the official who finds himself responsible for an accident, even though the responsibility be of such a sort that the courts of law could never fix it upon him.

Will there be anything gained, then, by branding such a man as a felon and shutting him up in prison? Is it not a fact that were society to go to an extreme in its severe treatment of men in responsible positions, it would soon find that the better class of men would not take such positions with the risk involved? "Punch's" advice to tie a director to the front of a locomotive is often quoted; but it never seems to occur to anyone that directors might prefer to resign under such circumstances, and that difficulty might be found in filling their places.

Turning from the general back to the specific case of the Park Ave. tunnel disaster, we think it entirely probable that the Grand Jury was right in its refusal to find criminal indictments against any officer of the New York Central & Hudson River R. R. That the company was blamable for the condition of its tunnel we have repeatedly stated; but that this blame could take the shape of individual criminal responsibility, such as could be legally established in a court of justice, there is no reason to believe. The District Attorney, in the course of the coroner's investigation, expressed great disgust at the failure to find a single party on whom responsibility for the accident could be fixed; but it is the rare exception when the blame for any disaster can be so localized.

In the New York Central disaster, Wisker, who ran his engine past the signal, was the agent immediately responsible; and him the Grand Jury indicted; but attempt to go back of him and what a maze we reach. Wisker ran past the signal because it was obscured by smoke, and because he was not familiar enough with the tunnel to know when he reached the signal. Then the search for responsibility divides, going in one direction to find who placed Wisker on the locomotive, and who was responsible for a system that permitted an engineer of limited experience to be given such a task. In the other direction, the attempt is made to find who is responsible for the obscuring of the signals by smoke. The directors place the blame on the engineers who designed the tunnel, thirty years ago. If we press the inquiry as to why in all the years since the tunnel was completed, something has not been done to better its condition, we meet the fact that all railways have neglected the matter of tunnel ventilation, and the New York Central officers can fall back on the defence that its tunnel was no worse than many others. To attempt to follow the inquiry farther would make necessary, probably, such a searching of hearts as no court of law has the power to undertake. What has the attitude of the controlling stockholders been toward expenditure of money for improvements? Have the directors welcomed criticism of existing methods and systems from their executive officers, or has the man who condemned old methods and urged radical improvements written his own resignation at the same time? Have the executive officers been furnished with means and facilities to cope with the large problems in connection with their work or have they had to give their time and strength to petty routine and details?

So we might continue, but there is no need. We desire only to show the method of inquiry which must be pursued to fix the responsibility for such disasters as this; and to illustrate the great difficulty of apportioning by the criminal law the actual responsibility therefor.

Again, to show the futility of criminal prosecution as a protection to the public from accidents, let us take the dynamite explosion on the Rapid Transit subway on Jan. 27. The sub-contractor on whose work the explosion occurred is said on good authority to have been the most careful and cautious in his care of explosives of any contractor on the entire work. He was an educated and thoroughly experienced engineer, and he gave his unremitting and zealous personal attention to his work; yet, through an infraction of strict orders by a workman, according to the present information, all his precautions went for nothing and an explosion was brought about which will render him bankrupt, and in addition, subjects him to prosecution as a criminal. It may well be asked whether society is the gainer in the long run by the exaction of this latter penalty.

Take still another recent case to show the difficulty of tracing responsibility. On Nov. 26 last the four-story factory of the Penberthy Injector Co., at Detroit, Mich., was wrecked by the explosion of a cylindrical shell boiler in the basement of the building, and some 30 persons lost their lives. An investigation by experts shows that the failure of the boiler was due to poor material and poor riveting; The shell contained too much phosphorus, the rivet holes were unevenly spaced, and had been made to match by a drift-pin; a crack formed in the shell near the seam, and finally the boiler exploded. Now, how can we place the criminal responsibility for the loss of these thirty lives? Can we go back to the boiler shop where the boiler was built ten or a dozen years ago, and find to what extent workmen, foremen, superintendent and owner were severally responsible for the condition of the boiler as originally completed? Must we not inquire also to what extent the inspectors of the boiler were responsible for failure to discover its dangerous condition, and even investigate the propriety of placing a shell boiler in a position where its explosion could work such widespread damage?

Another notable recent boiler explosion illustrates even more forcibly the difficulty of placing criminal responsibility. On Aug. 28, the boilers of the steamer "City of Trenton," plying on the Delaware River exploded, causing the loss of 26 lives. The immediate cause of the explosion, according to the best information, was probably low water; but the secondary cause was the use on the boat of a type of boiler that ought never to be used in marine service, because constant attention is required with it to make sure that the crown-sheet is covered with water. To trace out the responsibility, therefore, we must find who was responsible for the adoption of this type of boiler. Did the owners insist on it through ignorance? Were they warned by the builders or by their engineer of its defects; or were all alike ignorant of them? Such boilers had been used before in steamboat service; let us not, then, blame too severely those who chose it in this case.

We might continue indefinitely such illustrations; but those already presented must convince any fair-minded man that criminal prosecutions of those responsible for accidents can seldom operate for the public benefit. There may occur exceptional cases where responsibility for criminal negligence can be brought home to an individual in a manner to justify prosecution and punishment; but in the great majority of cases it will be found that responsibility for the causes leading up to an accident is divided among many men. Careful investigation will also usually show that even when the responsibility can be accurately apportioned, imperfect knowledge, defective systems and failure of subordinates, rather than wilful and deliberate intention to create a source of danger, must fairly be credited against those on whom we find the responsibility to be placed.

In arguing against the criminal prosecution of officials in executive charge, however, we do not mean to say that such calamities as those we have instanced should lead to no action for the better protection of the public. On the contrary, it is one of the crying needs of the times that these great casualties should be thoroughly sifted by expert investigators. This should be done, not so much for the purpose of placing responsibility on individuals, but on each system or device or method whose failure contributed to the disaster. Such investigations would be invaluable to reveal the weak points where danger lurks and would be the strongest influence toward better and safer methods of operation.

It is strange, indeed, that in this progressive land, the mediaeval coroner's jury is still almost the sole system which the law provides for the investigation of accidents. The absolute uselessness of this old system as a method of developing the practical lessons to be drawn from an accident has been so often demonstrated that it needs no proof.

What is needed for the investigation of accidents is a competent expert body, such as have been instituted by the Board of Trade in Great Britain, to inquire into railway accidents and boiler explosions. The establishment of such a system of governmental investigation here would effect more in the prevention of accidents than any other possible reform, and its possibilities in the saving of lives and property in other fields are almost equally great.

We have the beginning of such a system in this country in the investigations of railway accidents which are undertaken by State Railway Commissions in Massachusetts, Maine, New York and a few other states; and in the investigation of fires made by municipal fire departments and Underwriters' agents. It is only a beginning, however, and needs to be systematized, greatly enlarged in its scope and placed in the hands of competent experts to work the benefit of which it is capable.

Until some such intelligent and scientific system of tracing the lessons of a disaster takes the place of the antiquated "crowner's quest," progress toward the prevention of such disasters must be distressingly slow.

LETTERS TO THE EDITOR.

Monolithic Concrete Sewers.

Sir: I hardly think that monolithic concrete sewers can be considered as of very modern construction. In 1891 I constructed an egg-shaped concrete sewer (with manholes and ventilators) for the sewerage system of Victoria, B. C. This sewer was a monolith, 9,244 ft. long, 2 ft. × 3 ft. at the upper end, 2 ft. 10 ins. × 4 ft. 3 ins. at the lower. A full description appeared in "Trans. Can. Soc. C. E.," Vol. X., Part 1, 1896.

Your obedient servant, Edward Mohun, C. E.

Victoria, B. C., Feb. 27, 1902.

A Bad Way to Get Rid of the Waste Water from House Refrigerators.

Sir: I enclose you a sketch of a piece of plumbing work (the drip pipe of a refrigerator connected with the top of the bowl of a water closet—Ed.) recently brought to my notice, and while your valued journal is not technically one interested in mere plumbing, it would appear that the defects involved cover a far broader field. No doubt in large cities with efficient inspection and severe penalties it could not occur, but how are and will the public be protected in the numerous small cities and towns where no such protection exists?

It can be stated that the plumber remonstrated with the owner in this case, and it was connected at the latter's emphatic demand. Plumbers even in small towns are pretty well up in the best requirements of their trade.

To write to a technical plumbing journal will only

reach the trade which is well aware of the danger of such work, hence education of the higher professions seems to be the only course left. In these days of "touch the button" it would seem that to save the trifling labor of emptying drip pans outweighs health.

Yours truly, Murray Forbes.

Greensburg, Pa., March 3, 1902.

Derails and "Sand Tracks" on Inside Tracks at Crossings.

Sir: I am designing some interlocking plants that involve three or more parallel tracks, and hence forbid the use of the ordinary derail on the inside tracks. Can you give me any information bearing on the availability of a "sand track" for such a purpose. I should be glad if your readers would send in any experience or knowledge they have may have on this particular subject.

Signal Engineer.

(It would seem quite practicable to use the "sand track" under the above conditions, the derails being connected to rails parallel with the track rails, as is done with guard rails where it is desired to prevent a derailed train from turning aside and going down a bank, etc. These auxiliary rails would be slightly lower than the track or running rails, and would each be laid in a trough filled with sand covering the rail-heads. At two Y-junctions on the Chicago elevated loop there is a piece of track connecting the arms of the Y and forming a diverting track for trains which may pass a home signal indicating "stop." To prevent such a train from running beyond the Y and fouling a main track crossover which is in constant use, the rails of the diverting track are covered with sand for a length of about 100 ft.—Ed.)

Could an Asphalt Diaphragm in an Earth Dam Be Relied On?

Sir: Having read the editorial in your issue of Feb. 20, p. 153, advancing certain ideas in regard to water-tight dams, I would suggest possible objections to some of the designs proposed.

The editorial takes it for granted that under a great head of water, a thin sheet of asphalt supported by a flimsy construction of masonry and earth would be quite impervious. While I would not take direct issue with the editorial on this point, I would advise caution in the use of such construction for important work. I think that an incorrect idea of the true nature of asphalt and similar bituminous compounds now prevails. The popular idea of asphalt seems to be that by some mysterious attribute, this material will yield under pressure when it suits the convenience of the engineer and at other times it will show great resistance to pressure. In my opinion a more rational assumption is that asphalt and similar compounds will yield under long-continued pressures, while under a pressure of short duration they will show a high resistance, and ultimately break with a sharp fracture. Asphalt will yield under quite a low pressure if time enough is allowed. Applying this idea of asphalt to the design proposed in your editorial, we find that if the core wall should be ruptured suddenly at any point, the asphalt would not accommodate itself and retain its continuity, but would be ruptured also. On the other hand, should any great inequalities of pressure due to settlement of the embankment prevail for a long period, the asphalt diaphragm might be pinched through at the points of greatest pressure. Again, should any material breach in the wall on the down-stream side of the asphalt be made, the enormous pressure of the water might in time force the asphalt through the breach. I will not take up space by amplifying these suggestions as I think it will be conceded that they point to the conclusion that we should not put too much responsibility on a thin sheet of asphalt. Very truly,

S. Bent Russell.

77 East May St., St. Louis, Mo., March 6, 1902.

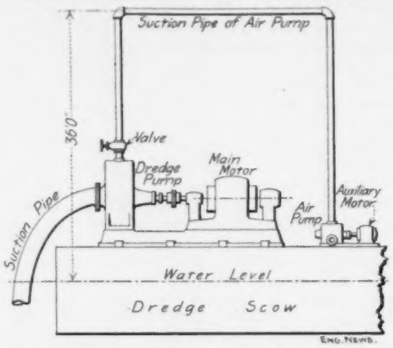
Priming Centrifugal Pumps Handling Muddy Water.

Sir: Noting in your issue of Feb. 27 an article by Mr. B. H. Heyward, of the Sand Pebble Phosphate Co., relative to priming centrifugal pumps operated where steam is not available for an ejector and where the material encountered would rapidly deteriorate an air pump if allowed to enter same, I would say that we have successfully accomplished this in the manner shown by sketch herewith.

The pump and suction pipe are primed by a small rotary air pump, direct connected with a separate motor; it is not advisable to operate the priming pump from the main pump shaft in any manner, as the main pump, if in operation, would in most cases carry water containing sand, etc., over the siphon and into the air pump. It is important, therefore, that the main pump should not be started until the valve on priming pipe just above main pump is closed; then start the main pump very promptly.

Any suitable type of air pump may, of course, be used for this purpose. A vacuum gage should, of course, be suitably located to observe the priming.

We have found that a strong and simple check valve with heavy rubber facing is most suitable for the discharge pipe; if the latter is of considerable



Arrangement for Priming a Motor-Driven Centrifugal Dredge Pump.

length the check valve should be placed near the pump, preferably next to same; but if discharge line is short, an open end flap check valve may be placed at outer end of same. The check valve should be placed in a horizontal or nearly horizontal run of piping. I believe this is nearly always possible with the ordinary arrangement of dredge pump discharge pipes. If the check valve is placed in a vertical pipe it is liable to the same faults as the foot valve from deposits of solid matter. Having the check valve near the pump and in a horizontal position is a decided advantage as it reduces the required displacement of air in priming and also reduces the shock to the pumping machinery in case of a sudden shut-down.

I may add that a tank as suggested by the editor would not prime the pump unless a foot valve was interposed on the suction pipe, and this is not desirable, for the reason given by Mr. Heyward that "in a shut-down the solid matter settles on the valve and it cannot be opened again." Solid matter is also liable to lodge under the flap and prevent it from closing, and in any case the valve will soon be worn out and useless. Foot valves should be discarded entirely whenever possible in dredge work.

Trusting that this may be of interest to your readers, I remain, Yours truly, E. F. Doty.

Camden Iron Works, Camden, N. J., Mar. 1, 1902.

(In our note suggesting an auxiliary tank to furnish water for priming Mr. Heyward's pump, it was implied, though not stated, that a special foot valve was to be used. This valve, it may be explained, should be arranged to remain open except when closed by hand for priming the pump from the tank; on starting the pump it would open automatically.—Ed.)

Cost of Building Macadam Roads.

Sir: I notice that Mr. Rogers, at the end of his interesting article on "Cost of Building Roads at Port Huron, Michigan," in your last issue, makes certain comparisons between Port Huron and Hudson, N. Y. It seems to me a little unfair to make comparisons of costs of certain items of these two pieces of work, as the conditions are somewhat different and Mr. Rogers' methods of distribution may not be the same as mine. It seems to me the only fair way to compare them is on the final cost of the finished roadway. Here again we have not the same conditions. The grading of 24th and Dove Sts. at Port Huron consisted in turnpiking the roadway with a road machine, while at Hudson the old roadway had to be spiked, excavated and carted away to a dump one-half mile distant, the roadbed carefully trimmed and graded to conform to the curb grades, as mentioned in my letter published in Engineering News of March 6. The spreading probably took more time on account of conforming to this crown and the gutters. However, I have reduced the cost of the Hudson work cited to the form of the foot notes of Mr. Rogers' Tables I. and II. These deductions give the comparative costs of the work in the two cities. The work covered by the total cost is equivalent as follows:

For 24th St., Port Huron, 2,900 ft. of road 9 ft. wide, costing $0.513 per ft., or at the rate of $2,703.36 per mile.

For Dove St., Port Huron, 1,320 ft. of road 9 ft. wide, costing $0.474 per ft., or at the rate of $2,506.40 per mile.

Diamond St., Hudson, N. Y., 4,228 ft. of road 9 ft. wide, costing $0.4175 per ft., or at the rate of $2,204.40 per mile.

The work at Hudson was performed on a ba[illegible] hours for a day's work. The sum of $12 per d[illegible] was paid for the use of the roller. The expens[illegible] neering was distributed to the items of grading, [illegible] ing, gutters, etc.

The method of hauling stone with the ste[illegible] and dump-wagons undoubtedly effects a great s[illegible] the hauling item. I doubt if this method could b[illegible] however, at Hudson, on account of the sharp [illegible] narrow streets and the heavy grades to be ascend[illegible] descended on the line of haul. The haul at Huds[illegible] double that cited at Port Huron. It was made wit[illegible] loaded by hand from stone piles and not from the [illegible] bins. The wagons are the ordinary hand dump-wa[illegible]. This item was much more than it would have bee[illegible] Mr. Rogers' improved method of transportation. [illegible] wagons had been of the improved self-dumping [illegible] and could have been loaded direct from the crusher [illegible] it would have made considerable reduction in the [illegible] ing item.

The point Mr. Rogers means to bring out, I take it, is that the use of the roller in transportation and the improved dump-wagons to spread the stone effects a great saving not only in the hauling item but in the spreading and rolling item as well. I fully agree with Mr. Rogers in this matter, and can only hope that I may be able to persuade the city to furnish me with dump-wagons for my future work.

The good roads movement is certainly making itself felt, and the makers of good road machinery are doing a great deal to make it a success. New machinery is constantly reducing the cost and improving the class of work done in macadam road construction. As in the case of Wyoming, Ohio, I am struck by the closeness of the figures of the cost per square yard in these different places, widely separated as they are in the United States.

H. K. Bishop, C. E.,
Superintendent Public Works.

Hudson, N. Y., March 8, 1902.

Slide Rule Computations for Laying Out Curves.

Sir: The article by Mr. Henry T. Stiff in Engineering News of Feb. 20, on "Slide-Rule Computations for Laying Out Curves," is a valuable introduction to the subject. Possibly it will not be out of the way to state as briefly as possible how the writer is accustomed to make these calculations after two years of practice with the rule.

In the determination of a curve, there are usually five elements to be stated, viz.:

I, the angle of intersection; D, the degree of curve; R the radius of curvature; T, the external tangent; and L the length of curve.

Almost always the central angle, I, is given, and either the external tangent or the degree of curvature is assumed. Considering the latter case first, the degree of curvature being assumed, the next element to be determined is the radius.

It is only necessary to remember that 5,730 ft. is the radius of a one-degree curve, and that the radius of curvature varies nearly inversely as the degree of curve, or, $R = \frac{5,730}{D}$. In order to compute from the rule at once the radii of other curves by this formula, reverse the slide, i. e., turn it up side down and place the index of scale C to 5,730 of scale D. Scale C then becomes a scale of degrees and scale D becomes a scale of radii.

The next element to determine is usually the external tangent. To do this, pass to the well-worn formula: $T = R \text{ Tan } \frac{1}{2} I$. Assuming that I is given, turn the slide over and retain the runner so that it indicates the radius on scale D, place the index of the tangent scale to it, and, passing the runner to the angle $\frac{1}{2}$ I, the external tangent is there indicated. In case the angle $\frac{1}{2}$ I should exceed 45°, we have this formula to help us out. $\text{Tan } \frac{1}{2} I = \frac{1}{\text{Tan } (90° - \frac{1}{2} I)}$. In such case, having the runner indicating the radius, we pass the angle on the tangent scale $90° - \frac{1}{2}$ I to the runner, and the index in this case indicates the external tangent.

On the other hand, it is sometimes necessary to determine the degree of curvature, having given the central angle and the length of the external tangent. To do this most easily, combine the two formulas: $T = R \text{ Tan } \frac{1}{2} I$ and $R = \frac{5,730}{D}$, giving $T = \frac{5,730 \text{ Tan } \frac{1}{2} I}{D}$. To make use of this formula on the rule, turn the slide over for the tangent scale, set the index to 5,730, and pass the runner to the angle $\frac{1}{2}$ I. Leaving the runner there, turn the slide over and reverse it. Set the index of scale C to the runner. We now have indicated on scale D at the index opposite the runner the external tangent for a one-degree curve. Scale C becomes a scale of degrees, and scale D a scale of corresponding external tangents for any degree of curve.

To determine the length of a curve with the rule, degrees and minutes must be reduced to degrees and decimals. To do this set 1 to 6. The first scale will show the

decimal corresponding to minutes on the second scale. The actual process of division by means of the rule will give the required length.

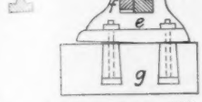
It will probably be objected by those who regard accuracy as the greatest desideratum of engineering, that these methods of finding the radii of curves are only approximate. In a 20° curve the error from this approximation is greater than 1.4 ft. Those who use a magnifying glass in reading the rule may possibly be able to read closer than this. I have frequently read within 2 and 3 of a fourth figure. Those who desire such close accuracy would do well to leave the slide rule alone. To those, however, who do not care so much for minute details, but who want the larger figures always correct, the slide rule is an indispensable instrument, very fascinating in its use and about which there is always something mysterious and unknown because of the infinite variety of its application. Yours truly, Frank Cooper,

Assistant Engineer Little Kanawha Railroad Co.

Parkersburg, W. Va., Feb. 27, 1902.

The Inventor of the T-Rail.

Sir: Replying to your comment on my communciation in your issue of Feb. 13, I enclose a sketch of the rail section given by Millington. While he does not say that this is Birkinshaw's section, he says that it is the section most generally used and that Birkinshaw gave the last stage of improvement to railways by the invention of his rail section, so I presume that Birkinshaw's section was similar to, if not identical, with the enclosed sketch. This section undoubtedly is a T-rail section and has the head, web and flat-bottomed flange of the modern section. The older cast-iron fish-bellied rail and the Jessop edge-rail each had a head and a vertical web, but they had no part to correspond with the bottom flange of the modern T-section. I think that the addition, by Birkinshaw, of this bottom flange "to promote stiffness" constituted the final step in the invention of the so-called T-rail section. Stevens modified this section by widening the bottom flange and then substituted the grip of his hook-headed spike on the edge of the flange for the grip of the cast-iron chair on the flange of the Birkinshaw section. By reference to the accompanying sketch from Millington's book, it will be observed that the function of the cast-iron chair shown is very similar to that of the modern spike and tie-plate in combination and that very little, if any, reliance is placed in the bracing action of the chair as it extends but a comparatively short distance up on the web. Very respectfully yours,



Rail Sections from Millington's Civil Engineering.

W. M. Dawley, C. E.

B. & O. R. R., Zanesville, O., Feb. 17, 1902.

(The sketch above shows a narrow-flanged rail carried on a large cast-iron chair, the flange being cut away on one side to admit a wedge or key driven horizontally between the rail and chair, somewhat as in the old "Providence" style of street railway track. No dimensions are given and it is impossible to say how accurately the very small sketch represents the actual form of the rail, but the flange is so narrow that the rail could hardly be called self-supporting. Without a correct drawing it is impossible to make comparisons. Some of the cast-iron fish-bellied rails had the same style of stiffening rib. According to other descriptions of Birkinshaw's rail, the so-called flange was little more than a stiffening rib on each side of the web, and other rails of the same general form had the stiffening rib made more in the form of a bulb than a flange. The drawing of his rail (1820) shows a T-shaped rail, with flat web and no rib or flange. Whatever the actual form of Birkinshaw's rail, it does not seem to have been a flange rail in the present meaning of the term, and it was intended for use with the clumsy and ponderous cast-iron chairs which are still used in England. His patent specifications (1820) state that "the upper part is to rest on supporting blocks, chairs, and sleepers." Birkinshaw simply strengthened and improved the rail for the then existing type of track. Stevens, however, in studying over his rail, designed a section that was essentially self-supporting, and, therefore, made a track entirely different from that made with any previous rail. This is the essential difference between the two. Incidentally, his rail had bolted splice joints and spike fastenings, practically as in the rail of to-day. The Stevens rail was shown in our issue of Nov. 2, 1889, and some old American edge rails in our issue of June 16, 1898.—Ed.)

Mr. Worthington's Design for a Non-Continuous Swing Bridge.

Sir: Replying to letter in current issue of Engineering News, signed by "Old Fogy," and criticising my design for a non-continuous swing bridge, as described in your issue of Feb. 27th, I have to say:

As to whether the design evolved by Old Fogy some 20 years ago, was exactly the same as my own, or even, as he claims, "exactly similar" to it, I cannot say, not having at hand any sketches illustrating the design referred to. If it was exactly the same, then Old Fogy may, if he wish, come forward with proper proof and take the patent that has been granted to me by an evident mistake, without cost to himself. If, on the other hand, it was only "exactly similar," that is another question, and then his design was probably only one of the many attempts which have been made to solve the problem of the non-continuous swing bridge, some only projected, some patented, and some even built, but all of which have been sooner or later "laid away in the scrap heap" by their designers, or at any rate have not been repeated in actual construction. Old Fogy's design was an exception, however, to the above, in that even the records of the Patent Office—that vast burying ground for those creations of man's mind commonly known as inventions—fail to reveal any signs of its existence; and here I take the old gentleman to task for a lack of common philanthropy in not erecting some such monument as a patent to mark the place where he stumbled, in order to point out the dangerous spot to those who might happen to pass that way in the future.

Referring now to Old Fogy's statement that "the strain sheets (I suppose he means 'stress sheets') are all easy, but when the question of operation was taken up" the scheme failed; this only goes to show that the so-called "strain sheets" were either incorrect or did not include all the different stresses that the component parts of the structure were to sustain—both inexcusable faults in any design.

So much for the sweeping general criticisms which seem to the writer as altogether impertinent in their application to a design so specific and with the details shown so clearly as was done in this case.

Referring now to the old gentleman's one definite criticism, namely, the effect of friction at the pins, the writer would say that he had examined into the effects of this friction at the joints, and found them to be so slight as to warrant being neglected, and the method of determining them so simple as not to require demonstration; but for the edification of Old Fogy, I will take that one of these pins on which the pressure is greatest, and show just what effect the friction will produce. Referring to the stress sheet, Fig. 2 on p. 168 of your issue of February 27th, the pin at B is subjected to a horizontal force of 166,000 lbs., and a vertical force of 120,000 lbs.; or, combining them, to a resultant force of about 205,000 lbs. (It might be well to note here that the reactions at end pins of the arms, as shown on this stress sheet, are not correctly located on the diagram; the reactions for bridge closed being substituted for those for bridge open, and vice versa.) Assuming the coefficient of friction of steel on steel at 0.2, the frictional resistance at surface of the pin developed by this resultant pressure, will be $0.2 \times 205{,}000 = 41{,}000$ lbs. This frictional resistance is to be overcome by pulling on the bars O C; assuming now a 6-in. pin at B, and finding the perpendicular distance from the bars O C to point B to be 438 ins., the additional stress produced in bars O C, in order to overcome the above resistance, will be $41{,}000 \times \frac{3}{438} = 281$ lbs., an amount scarcely appreciable compared with the stress already in these bars. So much for the effect of friction at joints as tending to retard operation of the mechanism.

In the matter of the allowable pressure per square inch of projected area of bearing surface on these pins, Old Fogy proposes to limit same to 800 lbs., considering it a case of an ordinary journal; now for comparison with this, the writer begs to quote from Unwin ("Machine Design") a value of 3,000 lbs. to be allowed in designing "bearings on which the load is intermittent and speed slow, such as crank pins of shearing machines." The pins in question, however, and their bearings should not be considered as journals, properly speaking, for the conditions are different; in this case the effect of friction, under the extreme condition of surfaces being unlubricated, is too small to be considered in its effect on the operation of the mechanism, and the motion too slight to consider the effect of heating; if, therefore, the pressure be within the limits required, to prevent crushing of the metal, then the problem is solved. Suppose, for example, two planed surfaces of steel are held in contact by a force of say 15,000 lbs. per sq. in., the value allowed for bearing of pin plates on pins by Cooper's Specifications; does Old Fogy think that a side thrust of sufficient magnitude to overcome the friction and move one of these surfaces over the other, will materially increase the tendency of the metal to crush? The motion will, of course, produce a certain amount of wear, but in the case under consideration, this motion is scarcely appreciable and occurs so seldom in most draw bridges, that its effect can be neglected altogether, or provided against by a slight increase in size of pins. One other effect of the friction on the pins is to produce bending in the individual truss members attaching to the pin, but the insignificance of this bending can be seen without further demonstration by a glance at the calculated effects of the friction given above.

Finally, notwithstanding the wholesale criticisms of the design in question by the writer of the above-mentioned letter, and which are backed by no proofs other than their statement, the writer still claims for his design a satisfactory solution of the problem to design a swing bridge which will be non-continuous when closed, and a lifting mechanism efficient and positive in action at all times, and very much simpler in construction then anything yet placed on the market for operating end lifts.

Respectfully, Chas. Worthington.

Pittsburg, Pa., March 7, 1902.

Notes and Queries.

In our issue of Feb. 20, in a note on the new steamers to ply between the Great Lakes and Quebec, it was stated that the vessels would have a cargo capacity of about 3,000 tons on 14-ft. draft through the Canadian canals. Our information was taken from a press dispatch, but we think it probable that the capacity should have been stated at 2,000 tons instead of 3,000, as a correspondent informs us that 2,000 to 2,200 tons is the maximum cargo that can be carried through the Welland canal.

O. B. M., New York city, asks the best ingredients for a fireproof mortar suitable for furnaces, etc., for fire-brick or stonework, capable of enduring great heat without cracking or dropping out.

Kaolin or fire clay is, we believe, universally used in laying fire-brick, and it is a good plan to get it from the same bed from which the brick themselves are made, so that there can be no chemical action between the brick and the mortar when intensely heated. For a moderate degree of heat, such as stonework will stand without injury, the recent tests of concrete under fire indicate that Portland cement mortar would stand very well.

"Old Railroad Engineer" comments on the illustration of a rock cut on the Cincinnati Southern Ry. in our issue of Feb. 20, p. 145, and says that the ragged appearance of the slopes is due to the use of excessive charges of dynamite in the excavation. He asks why it would not be a good plan for railways to take out the sides of such cuts by channeling machines, as was done on the Chicago drainage canal, and thinks it would save expense on maintenance afterwards.

We are inclined to think that most railways in this country would object to the expense of channeling-machine work. Under the very favorable conditions on the Chicago drainage canal, the cost of the channeling was probably 7 to 12 cts. per sq. ft. In many classes of rock the cost would be much greater, and the necessity of working the channeling ahead of the blasting might involve delay to the work. On the other hand, the ragged surface of a rock cut is not a pleasing feature. On many English railways one sees the sides of rock cuts carefully smoothed off. We may yet come to that in this country.

A NOVEL DESIGN FOR AN EARTH DAM.

A paper of much interest was presented before the American Society of Civil Engineers, at its meeting of March 5, by Mr. Geo. S. Morison. It described a design for a dam across the Chagres River, on the line of the Panama Canal. In presenting the paper, Mr. Morison outlined the current of thought that led him to his design, supplementing the matter given in his formal paper. The discussion by the members of the society was also highly interesting. Both paper and discussion, which are briefly abstracted below, touch upon some new phases of the subject of earth reservoir embankments.

The Bohio Dam, on the proposed Panama Canal, is a structure designed to impound the waters of the Chagres River and form a large reservoir—Lake Bohio—which is to maintain the summit level of the canal and supply the water for lockage of ships. It has been a part of all Panama Canal schemes since the formation of the New French Company, but until recent times the possibilities of the situation have not been fully appreciated. Some two miles on an airline from the site of the dam there is a rock saddle, Gigante Gap, on the boundary of the future lake, which presents ideal conditions for utilization as a spillway. This spillway may be designed so that with 7 ft. of water on the crest the discharge would take care of the maximum flood in the Chagres for an indefinite period. No spillway near the dam, as was provided in the plan of the New French Company, would therefore be required, and as the Bohio Dam is in a pocket away from the current determined by the spillway at Gigante Gap, the dam would be perfectly secure against overflow. Seepage or percolation through or under the dam would be the only way in which the water could act to destroy it.

The quantity of water available from the flow of the Chagres equalized by the reservoir is very much greater than is required for locking uses and other losses. The Gigante spillway will discharge this surplus into the back swamps of the Lower Chagres, so that none of the excess will flow through the canal.

Fig. 1 shows a contour map of the Chagres valley at the site of the Bohio Dam. The Chagres River here occupies only a small part of the geological valley, though outcroppings of rock either side of the stream banks concealed this fact until a large series of borings had been made at the site. The borings showed that the rock valley near the site of the dam is at some points as much as half a mile wide, and that the rock surface is at some points as much as 140 ft. below tidewater. The valley is filled with alluvial deposit of greatly varying character; the lower strata are generally permeable, the upper strata finer and practically impervious. Evidences were noted which tend to show that the permeable strata are connected with the river bed either above or below the site of the dam, but probably not within half a mile of it.

The construction of the Bohio Dam requires that the floods of the Chagres be properly taken care of until the dam is carried up to a sufficient height to discharge the water over the Gigante spillway. This introduces into the problem considerable difficulty and much additional expense. The two principal plans for the Bohio Dam hitherto proposed are (1) that of the New French Company and (2) that of the Isthmian Canal Commission.

THE FRENCH PLAN.—A cross-section of the proposed dam is shown at the top in Fig. 2. The surface material was to be excavated to a varying depth, but not beyond what it is believed could be done with open coffer-dams, and starting on the ground so laid bare an earth dam of compact material, but without a core wall, was to be built. This dam was to have a slope of 1 to 1½, broken by a reach of 1 to 2, on the down-stream face and of 1 to 3, broken by four flat benches, on the up-stream face. The width on top was to be 49 ft., 10 ft. above extreme high water and 75 ft. above tidewater. The entire down-stream slope was to be faced with rip-rap 3 ft. thick, the up-stream slope with concrete of the same thickness. A concrete wall was to be built across the river at the foot of the up-stream face between two lines of sheet piling. As a protection from possible floods during construction, a large amount of heavy rip-rap was to be placed on the down-stream face to prevent destruction of the work in case a flood should pass over the dam before completion. It was proposed to build a temporary dam of piles, timber and loose rock about 2,000 ft. above the permanent dam and to deflect the flow of the Chagres through the excavation for the locks. Should the capacity of these locks be exceeded by a flood, the rip-rap on the down-stream face of the permanent dam was expected to save the works. According to this plan, the construction of the dam could not really begin until the excavation of the locks had been completed, and work on the locks would be suspended while the dam was building.

This dam is, as stated, only 75 ft. high above tidewater. Its cost was estimated to be $1,134,066, on the basis of the prices used by the Isthmian Canal Commission. Fig. 2 shows, below, a similar section, but carried to elevation 100, which is the height to be used according to present plans. The cost of this dam is, roughly, $2,000,000; adding the cost of a temporary dam, and increasing the total by 20% for contingencies, the total would be $3,462,546. This enlarged section and the estimate of cost for same are given only for purposes of comparison with the other designs.

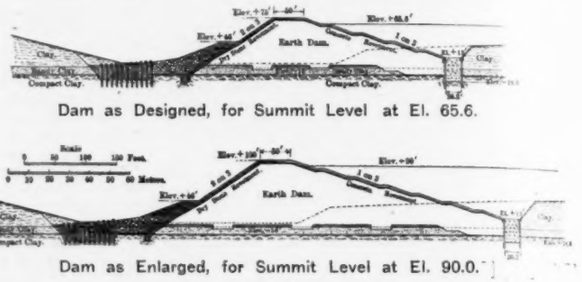
THE COMMISSION'S DAM.—This design is shown in Fig. 3. It is planned on the theory that the dam must form an absolutely water-tight closure of the valley. A masonry core wall carried down to rock forms this closure, and to make its construction practicable a site was selected that gave least maximum depth to rock. The site is some distance down-stream from that of the French dam, as will be seen from Fig. 1, and entails a total length of dam very much greater than at any other section. The concrete core wall is to be 8 ft. thick on top and 30 ft. at the base, resting on a series of pneumatic caissons sunk to rock; the joint between the caissons would be closed water-tight. The earth embankment around the core wall would be 20 ft. wide on top at elevation 100, with slopes of 1 to 3, broken by horizontal benches; both slopes would be revetted with loose rock. There can be little doubt that a dam of this character could be built, but it involves novel and untried features (the depth to rock is a maximum of 129 ft. below tidewater), and these, taken in connection with the climate and other surroundings, make the difficulties enormous. The estimated cost of this dam is $5,869,640. A temporary dam during construction would also be required; this would bring the total cost to $6,755,095, and, adding 20% for contingencies, this would become $8,106,114.

The ruling idea in this latter design, that of producing a perfectly water-tight closure of the valley, the author would reject entirely. Seepage through or under a dam is in general objectionable for two main reasons: Firstly, the value of the water may be so great as to make it worth while to prevent the percolation, and, secondly, the percolation may endanger the stability of the structure. As regards the first point, it has already been mentioned that a large amount of water would be constantly wasted over the spillway. If this surplus or any smaller amount of water be lost by seepage instead, certainly no harm is done. The second objection, that affecting the stability of the structure, may be met by proper design. Under these conditions, if a water-tight dam is very much more costly than one which permits a certain amount of seepage, the writer submits that it is good engineering to allow this seepage to continue.

On the basis of these considerations, the design shown in Fig. 4 was drawn up. The dam is to have a maximum width of about 2,200 ft., bounded by a rockfill dam at its up-stream and down-stream sides. The space between is to be filled with loose rock, earth and other material available. The top slope of the filling would be 4% down-stream, and, making the up-stream bounding dam 100 ft. high above tidewater, the down-stream bounding dam would require to be carried up to elevation 30. Just below the upper bounding dam a puddle wall 50 ft. thick would be constructed across the valley. This puddle wall is to extend down to tidewater and to rest over two lines of sheet piles 30 ft. apart, driven as far down as practicable, but probably not over 50 ft. below tidewater. For filling the great space between the bounding rockfill dams, i. e., to form the body of the embankment, there would be plenty of material available. Rock would be furnished in large quantities by the adjacent lock excavation; the remaining material could be brought up from the Bohio cut, but might well be taken from the northern bank of the great Culebra Cut, 17 miles away. To keep back the waters of the Chagres during construction, a temporary dam would have to be built, for which a tentative design is also submitted (not shown; the design provides for a combined steel and earth dam, with its crest at elevation 75, so as to discharge the water through the Gigante Gap.—Ed.).

The dam outlined above would be perfectly secure against destruction by water seeping through it; it could never be overtopped, as already pointed out, and burrowing animals would not affect its tightness. While it does not provide against is seepage through the pervious strata below the dam. This seepage, being nearly all of very low velocity, could be harmful only from the point of view of waste of water.

To estimate the amount of this seepage, we employ the formula given by Mr. Allen Hazen, M. Am. Soc. C. E., and based on his experiments at Lawrence, Mass. The effective size of grain (involved in the formula) was determined for the present case from samples obtained in making the borings, the coarsest material encountered be-



Dam as Designed, for Summit Level at El. 65.6.

Dam as Enlarged, for Summit Level at El. 90.0.

FIG. 2. BOHIO DAM, ORIGINAL AND TRANSFORMED SECTIONS. DESIGN OF NEW FRENCH COMPANY.

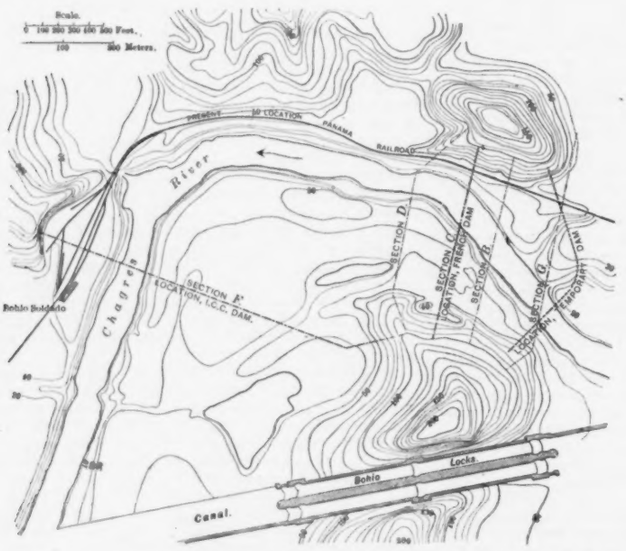


FIG. 1. CONTOUR MAP OF LOCATION OF BOHIO DAM, PANAMA CANAL.

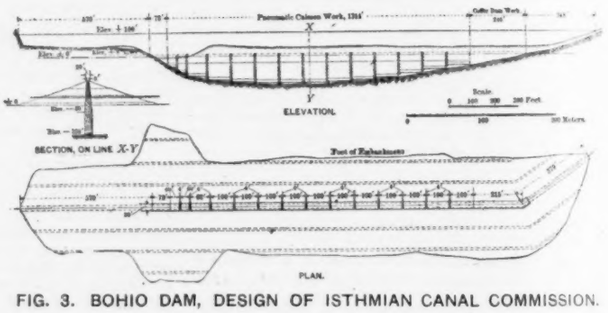


FIG. 3. BOHIO DAM, DESIGN OF ISTHMIAN CANAL COMMISSION.

ing used for this determination. The length of path of the water through this material under the dam was conservatively estimated as 2,500 ft. The amount of permeable material in the cross-section averages probably little over 10,000 sq. ft., but for this estimate 20,000 sq. ft. was used. If we take 1 mm. as the effective diameter of grain, a value probably much too large, the total seepage is found to be 40 cu. ft. per second. If all the factors be changed to values that might be expected, if not at first, then in a few years after construction, and the effective size of grain be taken as 0.5 mm., the seepage is only 2½ cu. ft. per second. Now, the flow of the Chagres as equalized would exceed 1,000 cu. ft. per second. Of this quantity only 500 cu. ft. would be needed for lockage and 200 cu. ft. for evaporation losses. There would thus be available for seepage and other losses at least 300 cu. ft. per second. The seepage as estimated is seen to fall very far short of this amount. The velocity of the seepage flow, also found from Hazen's formula, is less than 0.002 ft. per second—entirely insufficient to move any material. The rate of flow in the sand is greater than the above, being probably about 0.008 ft. per second.

The cost of the dam as designed was estimated on the basis of the same prices used in the two previous estimates. The permanent dam would cost $1,140,220; permanent and temporary work, $2,025,675; and if 20% be added, as before, the total figure is $2,430,810. In round numbers, then, we have as total cost of the three designs shown $3,500,000 for the French dam, $8,000,000 for the dam of the Isthmian Canal Commission, and $2,500,000 for the third design.

DISCUSSION.

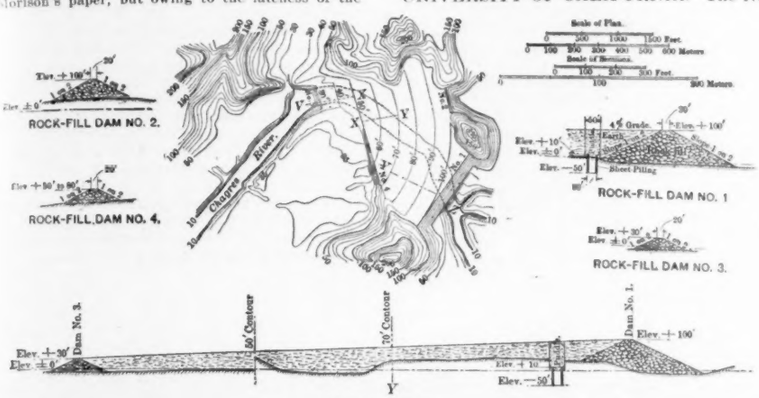
The paper of Mr. Morison mentioned the only known parallel to the proposed dam, both in conditions and design—the North Dike of the Wachusett Reservoir at Clin-

ton, Mass., now under construction. Mr. F. P. Stearns, President of the Metropolitan Water and Sewerage Board of Massachusetts, described this structure at some length and in a most interesting manner, illustrating his remarks with a number of drawings of sections of the dam and subsoil and many views of the work on the dam. We hope to present this paper fully in a future issue. A section of the (then proposed) dike was shown in our issue of March 7, 1895.

Mr. Allen Hazen explained his experiments at Lawrence, on which his experiments was based the formula used by Mr. Morison for estimating the seepage. He expressed the opinion that the formula is perfectly applicable to the case of seepage through the permeable strata under the Bohio dam.

Secretary Hunt had received several written discussions of Mr. Morison's paper, but owing to the lateness of the hour only one of these was read. This was by Prof. Wm. H. Burr, of the Isthmian Canal Commission. Prof. Burr made a lengthy defense of the Commission's design for the Bohio Dam. He referred to the scarcity of borings at the site and to the fact that what borings there were showed a most remarkable variation in kind and distribution of permeable material. He considered it probable that much larger amounts of this permeable material existed than were estimated by Mr. Morison. The method of obtaining samples from the borings he did not consider permitted any conclusive judgment as to the quality of the material, and nothing in the evidence precluded the possibility that there existed large veins of very great permeability. The wisdom of founding a dam on strata containing such veins connected with a reservoir of 90-ft. head he should strongly doubt. He also denied the applicability of Mr. Hazen's formula for calculation of the seepage to such a case. The Lawrence experiments, he said, in no way fitted the conditions here, their range in all the factors involved being entirely inadequate. He considered that it was the Commission's duty to adopt a plan by which the geological valley was closed entirely to the flow of water, and that any other plan involved too many elements of uncertainty to justify them in its consideration, even though the alternative was a greatly increased cost. As to the sinking of the pneumatic caissons to the great depth proposed, he stated that the plan was to lower the ground water level as much as 30 or 40 ft. by pumping, and thus reduce the air pressure in the caissons to limits recognized as practicable.

In reply to various points raised in the discussion, Mr. Morison confined himself to pointing out that if, as Prof. Burr asserted, the level of the ground water could be lowered by pumping as much as 30 or 40 ft., then it might safely be concluded that the conditions were such as to limit the seepage flow through the subsoil to a figure fully covered by the calculations given in the paper.



SECTION *VXYZ.*

FIG. 4. BOHIO DAM, DESIGN OF MR. GEO. S. MORISON, M. AM. SOC. C. E.

NOTES FROM THE ENGINEERING SCHOOLS.

LEHIGH UNIVERSITY.—This institution announces the following scholarships open to competition at the annual examinations in June, 1902: Two in the Classical Course, of $150 and $100; one in the Latin-Scientific Course of $125; one each in Civil, Mechanical and Electrical Engineering, in Mining Engineering and Metallurgy and in Chemistry, of $150 each. These sums will be paid to the successful competitors in two installments during the Freshman year; and they will be renewed from year to year, provided the holders thereof are in full standing in their studies. All fees, except those in the various laboratories, are remitted to those holding scholarships. To obtain them, the student must have the highest general averages in all subjects required for entrance to the above courses; but he must receive no mark below 70 in any course.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—At the last meeting of the Society of Arts of the Institute, Mr. Wm. Barclay Parsons, M. Am. Soc. C. E. and Chief Engineer of the Rapid Transit Railway of New York, delivered a lecture upon Engineering in China. Mr. Parsons also lectured on his experiences in China before the Technology Club. At the previous meeting of the Society of Arts, on Feb. 13, Prof. W. H. Burr, of Columbia University and the Isthmian Canal Commission, lectured on the Isthmian Canal question.

UNIVERSITY OF CALIFORNIA.—The November issue of "The University Chronicle," just received, contains an interesting paper on "The New Star in Perseus," by Director W. W. Campbell, of the Lick Observatory; the details of the observations of the star made at the Lick Observatory, having been published in the Observatory Bulletins Nos. 8 and 10. This new star was discovered on Feb. 22, 1901, by Rev. T. D. Anderson, a private astronomer in Edinburgh. In four days this star increased from the 11th to zero magnitude, or multiplied fully 25,000-fold in the intensity of its light. Assistant Astronomer C. D. Perrine, of the Lick Observatory, made the discovery of the almost incredible velocity of this new star, amounting to 11 minutes of arc in seven weeks.

LAFAYETTE COLLEGE.—On April 5 will be dedicated the new Laboratory of Chemistry and Metallurgy, erected with money donated by Mr. James Gayley, M. Am. Inst. M. E., of the Class of '76, now First Vice-President of the U. S. Steel Corporation. The Henry W. Oliver Library of Chemistry will be formally opened at the same time. All former students of Lafayette are invited by President E. D. Warfield to be present at the exercises on that date.

A FOUR-CYLINDER LOCOMOTIVE WITH CRANK axle has been built by the Baldwin Locomotive Works for the Plant System railways, and is No. 20,000 on the builders' books. The design is that of Mr. W. E. Symons, Superintendent of Motive Power of the railway, and Mr. S. M. Vauclain, of the Baldwin Locomotive Works. The engine is of the ten-wheel type, but with the peculiarity that the first driving axle is the main axle. The high-pressure cylinders are 15 × 26 ins., 19 ins. c. to c., placed inside the frames and driving a crank axle 8½ ins. diameter. The outside low-pressure cylinders are 25 × 26 ins., 6 ft. 7 ins. c. to c., and these also drive the first axle. Only two 15-in. piston valves are used, one to each pair of the cylinders, each valve having three heads on a single stem. The two cranks are set at right angles, and the crank pins in the wheels are set at 180° with the nearest cranks. The boiler is of the Vanderbilt type, with corrugated furnace, 55 ins. diameter. The driving wheels are 6 ft. 1 in. diameter, with a wheel base of 14 ft. 1 in., the total wheelbase being 29 ft. 2 ins. The engine weighs 176,500 lbs., with 127,000 lbs. on the drivers. The tender is of the Vanderbilt cylindrical type, mounted on two trucks with cast-steel frames.

THE NEW YORK & JERSEY RAILROAD CO. is to finish the old Hoboken tunnel under the Hudson River, and has issued a prospectus. According to this document Mr. Wm G. McAdoo is President; the Vice-Presidents are W. G. Oakman, President of the Guarantee Trust Co., and Edmund C. Converse, former President of the National Tube Co.; Mr. C. W. King is Secretary, and Charles M. Jacobs is Chief Engineer. The directors are men prominent in railway and industrial corporations, including Mr. E. H. Gary, of the U. S. Steel Corporation. The capital stock is $8,500,000—including $3,500,000 of 6% non-accumulative preferred stock, and $7,000,000 of 5% bonds. Of the bonds $4,500,000 will be used in acquiring the property of the Hudson Tunnel Railway Co., and the completion of the north tunnel and its approaches and the equipment of the same with electricity. Of this north tunnel only 1,580 ft. of the part under the river remains to be built and it will carry two tracks for electric street cars. As the tunnel is only 18 ft. clear diameter inside the circular cross section, it will take some squeezing to get room in it for two cars to clear each other and special cars will be built for the service.

AN EXPOSITION OF HYDRAULICS AND NAVIGATION is to be held at Dusseldorf, Germany, in connection with the ninth International Congress of Navigation, to be held June 29 to July 5, 1902. Owing to limited space the exhibits will be confined to models, plans, photographs, printed work, etc. Application for space should be made at once—before April 1, to the General Secretary, Geheimen Baurath Sympher, Berlin W. 66, Wilhelm Strasse, 80. Blank applications and copies of regulations are filed for reference with the U. S. Bureau of Foreign Commerce.

CONSTRUCTION OF THE FORBES HILL RESERVOIR AND STAND-PIPE AT QUINCY, MASS.*

By C. M. Saville, M. Am. Soc. C. E.†

(With two-page plate.)

The work described was recently done under the supervision of the distribution department of the Metropolitan Water and Sewerage Board. Mr. F. P. Stearns, M. Am. Soc. C. E., is chief engineer of this board, and Mr. Dexter Brackett, M. Am. Soc. C. E., engineer of the distribution department.

The object of the work was to furnish storage and protection to the southern part of the Metropolitan Water District in case of accident to pumps or mains, and to provide for sudden and unusual drafts. For this purpose Forbes Hill was selected, situated in Quincy, a southern suburb of Boston, about eight miles out on the New York, New Haven & Hartford R. R. This hill was principally composed of unstratified glacial drift or hardpan, and its summit was about 190 ft. above mean low water in Boston Harbor. In designing the work it was planned that the reservoir should have a capacity of about 5,000,000 gallons and should be so placed that the excavation and embankment should about equalize each other. The stand-pipe was designed to hold about 300,000 gallons, with its overflow at about the elevation of Fisher Hill Reservoir, in Brookline, into which the same pumps at Chestnut Hill also deliver water. From the indications of a test pit it was estimated that the material was of a nature to form an excellent embankment, which, with a concrete lining, could be made impervious to water.

The reservoir, Fig. 1, is oblong, with its long axis running east and west. The bottom is 280 × 100 ft. and slopes slightly to a center drain, which pitches to a sump in the west end. The inner slope is 1 on 1¾, and is covered with two layers of concrete, separated by a plaster layer. The top of the bank is about 17 ft. wide and in the center is a granolithic walk 6 ft. wide, extending around the reservoir. The outer slope is 1 on 2, and is covered with loam and laid down to grass. The gate chamber is located at the west end, partly in excavation and partly in embankment. On either side of the chamber granite steps lead to the walk about the reservoir. Nearly opposite the gate chamber is the steel stand-pipe, 30 ft. in diameter and 64½ ft. high, resting on a heavy concrete foundation in which is a vault containing the gates controlling the water in the stand-pipe. The stand-pipe is enclosed in a granite masonry tower, the roof of which, reached by a circular iron stairway, can be used as an observatory. The reservoir and stand-pipe are now finished and in use, while the work on the tower is nearly completed.

On July 7, 1900, the contract for building the reservoir and stand-pipe foundation was awarded to the lowest bidders,‡ Beckwith & Quackenbush, of Mohawk and Herkimer, N. Y., who about a week later commenced work. The nearest public street to the work was about 900 ft. distant, from which the approach to the reservoir site was up a gradual rise of about 10 ft. per 100, partly over a private street and partly over the open hillside. A single drum hoisting engine with a wire rope was used to help haul heavy loads up the hill.

EXCAVATION AND EMBANKMENT.

The reservoir site was first stripped of loamy material to a depth of about 2¼ ft. A sufficient quantity for future

*Abstract of a paper read before the New England Water-Works Association on March 12, 1901. The paper will be published in full in the "Journal" of the association.

†Division Engineer, Distribution Department Metropolitan Water-Works, 1 Ashburton Place, Boston, Mass.

‡The canvass of bids for this work was published in Eng. News, July 5, 1900.

use on the banks having been placed in spoil banks, the remainder was placed in a berme, built on the northerly slope, where the built-up bank was highest. The cost of this work is shown in Table I. After the soil was excavated the material was found to be very compact and hard to excavate, water from rain or hose standing on the surface till evaporated rather than absorbed. In the excavation for gate chamber and pipe trenches the sides were carried down vertically for 20 ft. without bracing. Twice this excavation was filled to a depth of 12 ft. with rain water which fell in the reservoir, but when pumped out no damage was apparent. Blasting with powder was tried for loosening the material, but was soon abandoned. Some success was had by wetting the surface each night with a hose. In the latter case it was necessary to excavate the damp material before it became dry and hard.

In starting the embankments the ground was first thoroughly cleaned of all loamy material to a depth of about 2½ ft. for a distance in and from the outer toe of the slope equal to about one-third the width of the bank. At this point a quick drop of about a foot was made for another one-third of the width, where a second drop of a foot was made and the excavation carried at such a depth that at the inner edge of the slope the original material would be removed for a depth of about 5 ft. This method stripped all soil from under the banks and practically removed all material from under the inner third of the bank which could have been disintegrated by frost.

The bank was started in the lowest places, the undisturbed material being well wet and thoroughly rolled before placing other material upon it.

All the excavation, except a few hundred cubic yards in the bottom of the reservoir, was done with either drag or wheel-scrapers drawn by two horses. The ordinary gang employed on the work in the hardpan was made up of a four-horse hitch on a pavement plow, with one man driving and one or two men on the handles; from four to six scrapers, depending on the length of haul; an extra pair of horses, called a "snap team," for helping load the scrapers; a man on the scraper handles during loading, and, if the material was very compact, from two or three extra men to complete the load with shovels. The haul for the wheel scrapers was from 250 to 300 ft., and for the drag scrapers about one-fourth of this distance. The wheel scrapers theoretically held ¾ cu. yd., but in the material here excavated only about ⅝ cu. yd. could be readily loaded automatically. Even with this small amount per load, if properly regulated for distance and number an immense amount of material could be moved in a short time at small expense. Under favorable conditions each team averaged 35 cu. yds. per day, making from 8 to 10 trips per hour.

While the banks were low and the haul short a trial was made to determine the relative economy of carts and scrapers. Single dump carts were substituted for scrapers, with one of the scraper gangs, and a careful record kept of the work. Without including general superintendence and cost of loosening the material, which was the same in either case, it was found that four scrapers, one snap team and four men, besides the drivers, moved to the banks 100 cu. yds. of hardpan in five hours at a cost of 15½ cts. per cu. yd., while six carts with 14 men, besides the drivers, moved 75 cu. yds. at a cost of 24 cts. per yd.

Three rollers, weighing each about 4,000 lbs., and drawn by two horses, were used on the banks. These rollers were composed of gangs of separate cast-iron wheels, the alternate ones being of larger diameter than the others. Two of these rollers were 4 ft. wide and the other 6 ft. In order to provide for wetting the bank, and later for the concrete work, a 1½-in. wrought-iron pipe, with hose connections about 50 ft. apart, was laid around the reservoir site, a distance of about 1,500 ft., and connected at each end with the 24-in. main. This pipe was found rather small when considerable drafts of water were necessary. A ¾-in. hand hose was used on the banks, with a nozzle throwing a fan-shaped stream. By this means water could be quickly applied when needed and wet places avoided. The banks were put down in layers 4 ins. thick before rolling. Parallel with the bank they were level and crosswise had a slope of about 1 in 50 toward the reservoir until within 3 ft. of the top, where this slope was gradually changed to pitch outward, to keep drainage from the graded slopes and soft concrete. Just before placing the dry material on the bank the place would be thoroughly soaked, then the dry material dumped and partially leveled by the edge of the scraper. Laborers then spread the layer evenly, picking out stones of larger diameter than 3 ins., especially those that would project above the layer when rolled. Great care was also taken that numbers of small stones should not lie together, but should be separated by the hardpan. When a sufficient length was spread the roller was run over it three or four times without wetting. After this it was wet and rolled till it had a fresh, bright appearance and the wheels of the roller left only a slight impression. Sufficient water was applied to keep the material plastic, but not liable to peal in front of the roller. At the southwest end of the reservoir the banks were left low for a time on account of a roadway for transporting materials.

In order that the portion of the banks near the inner slope might be rolled as thoroughly as other portions, the bank was built with an extra width of 1 ft. and afterwards trimmed to grade. The trimming of these slopes and the grading of the bottom were the most expensive portions of the work. The banks were first plowed and then the material cast down to the bottom. The final trimming was done by men with picks and shovels. This portion of the material was removed in two-horse self-dumping carts holding from 1 to 1⅛ cu. yds. each. The method employed was to have two carts to each pair of horses, and while one cart was on the way to unload the other was being filled. This utilized the horses to their utmost and also set a pace for the laborers.

In November, 1900, as it was impossible to complete the work before severe weather, it was decided to fill the partially-completed reservoir with water to protect the banks. To protect the slope at the water edge, a belt of riprap, about 5 ft. wide and 6 to 8 ins. thick, was laid around the reservoir. Water was admitted very slowly, the level being raised at the rate of about 8 ins. per day, in order that the banks might not be too suddenly disturbed. No leakage was apparent during the winter, the surface of the water lowering only as much as could be ascribed to evaporation. In the spring the water was drawn off slowly. At first the rate of lowering was about 1½ ft. per day, but a slide of a few cubic feet caused this rate to be lowered about one-third, and no further trouble was experienced. Before leaving the work in the fall, levels were taken over the banks and in the spring they were again taken, but no settlement was apparent.

After the hardpan banks were finished and the concrete work nearly done, yellow and black loam was taken from the spoil bank and placed on the outer slope of the reservoir bank. This work was done by scrapers, which were found to be very wasteful, dropping large quantities in the long haul.

It was estimated that the equivalent of 1,043 cu. yds. of solid stone were removed from the material rolled into the hardpan portion of the banks. Most of this stone was removed to stone piles and afterward crushed for use in the concrete. A considerable portion was buried at the toe of the outer slope and under the berme. To provide drainage for water that might collect here, cross ditches filled with stone were dug through the berme.

Table I. shows the cost of the work in detail. The average pay for labor was 15 to 17 cts. and for two-horse teams 45 to 50 cts. per hour.

Material excavated for use in main portion of reservoir banks, cu. yds.	17,466
Volume in main portion of reservoir banks (estimated), cu. yds.	15,474
Shrinkage in material excavated, cu. yds.	1,992
Per cent. of shrinkage	11.4
Material excavated for use as above, cu. yds.	17,466
Estimated equivalent amount of solid stone removed from same, cu. yds.	1,043
Per cent. of solid stone removed	5.9

CONCRETE MASONRY.

Concrete masonry (Class A), composed of 1 part of Portland cement, 2½ parts of sand and 4 parts of stone, was used for the walls and bottom of the gate chamber, for the walls and floor of the gate vault in the stand-pipe foundation, and for cut-off walls on the pipe line.

Concrete masonry (Class B), composed of 1 part of Portland cement, 3 parts of sand and 6 parts of stone, was used for the foundation of the stand-pipe and for the foundation of the steps of the gate chamber.

The bottom and slopes of the reservoir were lined throughout with two layers of concrete masonry, [illegible] by a layer of Portland cement plaster, ½-in. in [illegible]

Concrete masonry (Class C), composed of 1 [illegible] American natural hydraulic cement, 2 parts of [illegible] parts of stone, was used for the under layer of [illegible] on the bottom of the reservoir.

Concrete masonry (Class D), composed of 1 part [illegible] land cement, 2½ parts of sand and 6½ parts of [illegible] used for the under layer of concrete on the slope [illegible] reservoir.

Concrete masonry (Class E), composed of 1 part [illegible] land cement, 2½ parts of sand and 4 parts of [illegible] used for the upper layer of concrete on the bot[illegible] slopes of the reservoir.

It was specified that the cement should be [illegible] tested, that the sand should be of approved quali[illegible] that either clean gravel stone or crushed rock sh[illegible] used in the concrete.

None of the stones were to be larger than 2½ [illegible] their greatest diameter and those used in the upp[illegible] of the reservoir lining were limited to 1½ ins.

Fig. 2 is a view of the concrete lining for the slop[illegible] bottom in process of construction. The upper la[illegible] of the concrete lining was formed in blocks about [illegible] sq. on the bottom of the reservoir and 8 × 10 on the [illegible] These blocks alternated in both directions, [illegible] being first laid and allowed to set. The surface of [illegible] blocks on the slopes was left about 1 in. low and finished with a layer composed of the same proportions as the balance of the block, but stone dust, and stone less than ⅜-in. was substituted for the 1½-in. stone. This layer was applied before the under concrete set and was finished

FIG. 2. CONCRETE LINING FOR RESERVOIR SLOPES AND BOTTOM UNDER CONSTRUCTION.

to a firm, smooth surface, true to the required slope. About 3,850 lbs. of Atlas Portland cement, 270 bbls. of Beach's and 130 bbls. Hoffman natural cement was used on the work. The greater part of this cement came to the work in bags. The sand was of excellent quality, some coming from Avon, Mass., and the rest from local pits. The best was that which came from a near-by sewer excavation, where a water-bearing sand stratum was encountered. The bulk of the stone used in the concrete came from the hardpan excavation, and was crushed on the work. This stone was quite dirty and had to be washed before crushing. This washing and the handling of the stone from the ground, where it had been scattered by the teams which removed it from the excavation, accounts for the excessive cost of crushing.

Previous to setting up the crusher about 750 cu. yds. of gravel stones were used, brought from a local pit. These were very dirty, also, and needed to be washed. Some crushed stone was bought from the sewer contractors, spoken of above. Concrete of Classes A and B was put in by Messrs. Beckwith & Quackenbush, but during 1901, having on hand considerable other work at a distance, they made arrangements with Messrs. Taylor, Carr & Andrews, of Boston, contractors, for concrete work, to finish the concrete then remaining to be done. To these contractors the stone previously saved from the excavation and some of the gravel stones were sold.

The stone-crushing plant consisted of a 12-HP. Hoadley engine, belted to a 9 × 15 Farrel Foundry & Machine Co.'s crusher. The engine also ran the stone elevator and the revolving screen. The rated capacity of the crusher was 125 tons per day, but only about one-third this amount was ever actually turned out. The stone bin had a capacity of about 30 cu. yds., and was divided into three compartments: One for stone less than 1½ ins. diameter, one for stone 1½ ins. to 2½ ins., and the third for stone

TABLE I.—Estimated Actual Cost of Earthwork, Excavation and Embankment.

Total quantities moved, 32,334 cu. yds. Cost, $13,097. Cost, per cu. yd., $0.405.

Comprising the following

Group I.—Soil Excavation: To spoil banks and berme and from spoil banks to reservoir banks.

Quantity moved, cu. yds.	13,868
Cost	$3.243
Cost, per cu. yd.	$0.234

Group II.—Material used in reservoir banks and in backfilling trench.

Quantity moved, cu. yds.	18,466
Cost	$9.854
Cost, per cu. yd.	$0.534

Cost in Detail.

	Nature of work.	Cu. yds.	Loosening.	Scraping.	Loading carts.	Teaming.	Rolling banks.	Unloading & spreading.	Excavation from trenches.	Backfilling trenches.	Surplus trenches to reservoir bank.	Total cost, per cu. yd.
Group I.	a. Stripping	8,722	$0.034	$0.140	.....	.....	.....	$0.006	.....	.....	.....	$0.180*
	b. Yellow loam	3,601	0.054	0.223	.....	.....	.....	0.029	.....	.....	.....	0.306†
	c. Black loam	1,545	0.048	0.228	.....	.....	.....	0.096	.....	.....	.....	0.372†
Group II.	a. Major part of selected material for banks	15,786	0.109	0.222	.....	.....	$0.039	0.077	.....	.....	.....	0.447†
	b. Minor part trimming & grading slopes and bottom	1,500	0.562	.....	$0.306	$0.228	0.044	0.063	.....	.....	.....	1.203§
	c. Excavt'n, gate ch...	750	.....	.....	.....	.....	.....	.....	$0.005	$0.174	.....	0.779‡
	" st.-p. fndatn											
	" pipe trench.	430	.....	.....	.....	.....	.....	.....	0.605	.....	$0.339	0.944‡

*Loosened by plows; excavated and transported by scrapers. §Loosened and excavated by hand; transported by scrapers. ‡Loosened, excavated and backfilled by hand; surplus transported to reservoir banks by scrapers.

of larger diameter, which were to be returned to the ore mill. At first everything smaller than 2½ ins. was used, but it was found that so great a quantity of dust was coming as to give the result of adding more sand to the mixture. On this account the screens were changed and a portion of the dust discharged into a separate pile, and was later used in the surfacing of the upper layer of concrete on the slopes. The stone crushed on the hill weighed about 95 lbs. per cu. ft., and had about 46% of voids. The gravel stones weighed about 111 lbs. per cu. ft. and had about 40% of voids.

Instead of barrels for measuring the proportions of sand and cement, gage boxes, without bottoms, were used. The following sizes were found convenient.

Proportions.	Sand Box. Size.	Sand Box. Vol. cu. ft.	Stone Box. Size.	Stone Box. Vol. cu. ft.
1—2½—4	2' 9" × 2' × 1' 8"	9.25	5' × 4' 5½"	14.80
1—3 —6	2' 9" × 2' × 2' 0"	11.10	5' × 6' 8"	22.20
1—2 —5	2' 9" × 2' × 1' 4"	7.40	5' × 6' 6⅝"	18.50
1—2½—6½	2' 9" × 2' × 1' 8"	9.25	5' × 7' 2½"	24.05

All the concrete except that on the sides was put in rather wet and rammed till it quaked. On the sides of the reservoir a drier mixture was necessary to prevent flowing down the slope. Where possible a spade was used to puddle the concrete next to the forms and a fine smooth finish was given to the work.

As to the possibility of a concrete wall being impervious to water, attention is called to the partition wall in the gate house between the water chamber and the gate chamber. This wall is 23 ft. high, 11 ft. wide, and 3 ft. thick, and there is a head of 19.5 ft. of water against it. In dry weather there is no moisture on this wall, although no more care was taken with it than with other portions of the work.

All the concrete, when laid, was kept continually wet for at least a week, and after that occasionally sprinkled until it was covered or the work was completed.

The ordinary concrete gang was made up of a sub-foreman, 2 men gaging materials, 2 men mixing mortar, 3 men turning the concrete, 3 men wheeling concrete, 1 man placing, and 2 men ramming. All the concrete was mixed and placed by hand. Two gangs were ordinarily employed, placing about 20 cu. yds. per day, each, or about 1.43 cu. yds. per day per man. The concrete was turned at least three times before placing. Fig. 2 shows the concrete work and plastering under way.

Besides the gang on the concrete three plasterers and three helpers were employed on the upper layer on the slopes. The layer of plaster between the concrete layers was put down in strips about 4 ft. wide and finished similar to the surface of a granolithic walk. This layer was mostly composed of 1 part Portland cement to 2 parts sand, with a finishing surface composed of 4 parts cement to 1 part sand. Long strips of coarse burlap soaked in water were used to keep this layer wet and cool. In spite of these precautions some cracks appeared which were grouted before being covered with concrete. Three gangs, each of a plasterer and helper, were employed on this work, each gang laying about 700 sq. ft. per day.

After the banks were finished a granolithic walk, 6 ft. wide, was constructed about the top of the bank. This walk has a foundation of stone about 12 ins. thick, on top of which is a concrete layer 4 ins. thick at the sides and 5 ins. thick at the middle. This concrete is surfaced with granolithic finish about 1 in. thick. The walk was laid in separate blocks, about 6 ft. square, a steel templet being used to keep adjacent blocks entirely separate. The average gang employed on the concrete of the walk was six men and a single team, while two masons and a tender did the finished surface. The average amount of walk finished per day was 60 lin. ft.

The cost of the concrete work is shown in Table II. The quantities of cement and its distribution is shown in Table III., and the cost of the work to the commonwealth is shown in Table IV.

GATE HOUSE.

The front of the chamber, the steps leading to the top of the bank, and the sills for the stop planks, are of best quality Quincy granite. The treads of the steps, top of the sills, the coping and other trimming are six-cut dimension stone. The exposed portion of the front and

Fig. 5. View Showing Method of Hoisting Standpipe Plates.

wing walls are of rock-faced ashlar of an average depth of 10 ins. and is backed with concrete. The chamber is covered with Aberthaw sidewalk lights of standard construction.

The plan and sections of the chamber are shown in Fig. 3. By means of a 24-in. check valve, set to open only when the head on the main is less than that in the reservoir, the reservoir is held as a storage basin to be called on only in cases of emergency. The piping of the gate-chamber and stand-pipe is shown in the plans. The total cost of this work to the commonwealth is shown in Table IV., while the estimated actual cost of the work appears in Table V.

STAND-PIPE.

On July 17, 1900, bids were received for building the stand-pipe, and later the contract was awarded to Walsh's Holyoke Steam Boiler Works, Holyoke, Mass., for $4,425.

Based on the estimated net weight of metal in the stand-pipe the canvass of bids would have been as follows:

Walsh's Holyoke Steam Boiler Works, Holyoke	0.038 cts. per lb.
E. Hodge & Co., E. Boston	0.039 " "
Edw. Kendall, Cambridge	0.051 " "
R. D. Wood & Co., Philadelphia	0.073 " "

The stand-pipe is cylindrical, 30 ft. in diameter and 64½ ft. high. The bottom is composed of plates ⅜-in. thick. The sides consist of 13 courses of eight plates each, varying in thickness from 9-16-in. at the bottom to ¼-in. at the top. The lowest course is connected to the bottom by a 3½ × 3½ × ½-in. angle, and the top is stiffened by a 4 × 3 × ⅜-in. angle inside. The plates are of open-hearth steel, containing not more than 0.06% of phosphorous and having a tensile strength of not less than 54,000 nor more than 62,000 lbs. per sq. in., an elastic limit one-half the ultimate tensile strength, an elongation of not less than 26% in 8 ins., and a reduction of area not less than 50% at fracture. Such other tests and inspection was required as would insure first-class material.

Details of the foundation of the stand-pipe and tower are shown by Fig. 4. Fig. 5 shows the stand-pipe under erection. Fig. 6 is a view, and Figs. 7 and 8 are details of the tower.

The vertical joints in the five lowest courses have outside butt straps, while in the remaining eight courses these joints are lapped. All the vertical butt straps have two rows of rivets each side of the joint. The vertical joints in the 6th to the 9th courses inclusive are double-riveted and those in the remaining courses single-riveted. The horizontal girth joints are single-riveted and the joints in the bottom are made with inside butt joints with a single row of rivets each side of the joint. All calking edges were beveled with a planer, and all shaping done by cold rolling. All shop work was done at Holyoke, and on Oct. 18, 1900, the plates were on the ground ready for erection. The bottom plates and first course were assembled and riveted, resting on rivet kegs directly over their final location in the concrete foundation. After being tested with water to a depth covering the bottom angle this portion was lowered by means of jacks to the foundation. Outside and inside stagings hanging from the plates already in place were used during erection, and a gin pole,

TABLE II.—Estimated Actual Cost of Concrete Work.

Class "A"—Concrete 1:2½:5.

Portland cement	279 cu. yds.		
Cement	1.35 bbl. @ $2.23 =	$3.010	
Sand	.46 c.yd. @ 1.13 =	.521	
Stone	.74 " @ 1.13 =	.840	
Lumber for forms, a M. ft. @ 20.00 =		.495	
Labor: General expenses	.202		
Forms	.586		
Mixing and placing	1.147		
	=	1.955	
Cost, per cu. yd. (total)		$6.821	

Class "B"—Concrete 1:3:6.

Portland cement	284 cu. yds.		
Cement	1.07 bbl. @ $2.23 =	$2.390	
Sand	.44 c.yd. @ 1.13 =	.497	
Stone	.88 " @ 1.13 =	.994	
Lumber for forms, a M. ft. @ 20.00 =		.127	
Labor: General expenses	.154		
Forms	.214		
Mixing and placing	.967		
		1.335	
Cost per cu. yd. (total)		$5.337	

Class "C"—Concrete 1:2:5.

American natural cement	400 cu. yds.		
Cement	1.25 bbl. @ $1.08 =	$1.350	
Sand	.54 c.yd. @ 1.02 =	.347	
Stone	.86 " @ 1.57 =	1.350	
Lumber for forms, a M. ft. @ 20.00 =		.090	
Labor: General expenses	.08		
Forms	.10		
Mixing and placing	1.17		
		1.350	
Cost per cu. yd. (total)		$4.487	

Slope Finish (With "E" Concrete.)

Items.	Cost per yd. 3,600 sq. yds.	100 cu. yds.	1,322 cu. yds.
Cement	$0.048	$1.710	$0.129
Sand	.011	.390	.029
Stone	.026	.960	.073
Labor: Mixing and placing	.069	2.500	.189
Average cost (total)	$0.154	$5.56	$5.911

Plastering.

Portland cement	6,822 sq. yds.		
Cement	0.07 bbl. @ $1.53		$0.103
Sand	.012 c.yd. @ 1.02		.012
Labor			.083
Burlap			.002
Average cost per sq. yd.			$0.200

Class "D"—Concrete 1:2½:6½.

Portland cement	615 cu. yds.		
Cement	1.08 bbl. @ $1.53 =	$1.652	
Sand	.37 c.yd. @ 1.02 =	.377	
Stone	.96 " @ 1.57 =	1.507	
Lumber for forms, a M. ft. @ 20.00 =		.016	
Labor: General expenses	.177		
Forms	.121		
Mixing and placing	1.213		
		1.511	
Cost, per cu. yd. (total)		$5.063	

Class "E"—Concrete 1:2½:4.

Quantities.	Cost per cu. yd. 1,222 yds.	Cost per cu. yd. 1,322 yds.
Portland cement	1,322 cu. yds.*	
Cement 1.37 bbl. @ $1.53	$2.09	$1.940
Sand .47 c.yd. @ 1.02	.48	.441
Stone .745 " @ 1.57	1.17	1.088
Lumber forms, $20 a M. ft.	.25	.277
Labor: General expenses	.15	.143
Forms	.26	.236
Mixing and placing	1.53	1.416
Average cost, a cu. yd.	$5.93	

Granolithic Walk.

Portland cement ..... 695 sq. yds.

	Sq. yd.	Cu. yd.
1. Stone foundation ..... 232 cu. yds.		
Stone	$0.134	$0.40
Labor: Placing, etc.	.502	1.50
Average cost	$0.636	$1.90
2. Concrete base ..... 90 cu. yds.		
Cement 1.22 bbl. @ $1.53..	$0.242	$1.87
Sand .50 c.yd. @ 1.02..	.066	.51
Stone .84 " @ 1.57..	.170	1.32
Labor	.450	3.48
Average cost	$0.928	$7.18
3. Top finish ..... 695 sq. yds.		
Cement 0.11 bbl. @ $1.53..	$0.168	.....
Sand .22 c.yd. @ 1.02..	.022	.....
Lampblack	.008	.....
Labor	.149	.....
Average cost	$0.341	.....
Total average cost, a sq. yd	$1.905	

*Excepting slope finish, 1,222 cu. yds.

TABLE III.—Showing Distribution of Cement Used in Concrete Masonry for Reservoir Lining, Gate Chamber and Foundation for Stand-Pipe.

Designation.	Proportion.	No. of barrels.	Quantities. Cu.yds.	Quantities. Sq.yds.	Amount laid per barrel of cement. Cu.yds.	Amount laid per barrel of cement. Cu. ft.	Amount laid per barrel of cement. Sq.yds.	Barrels of cement per Cu.yds.	Barrels of cement per Sq.yds.
Concrete—Class "A"*	1:2½:4	377	279	.....	0.74	20.0	....	1.35	....
" " "B"*	1:3:6	304	284	.....	.94	25.4	....	1.07	....
" " "C"†	1:2:5	500	400	.....	.80	21.6	....	1.25	....
" " "D"	1:2½:6½	664	615	.....	.93	25.1	....	1.08	....
All except slope finish	1:2½:4	1,674	1,222	.....	.73	19.7	....	1.37	....
Slope finish.‡	1:2½:4	112	100	3,600	.89	24.0	32.1	1.12	0.03
Plaster:§ Base, ½-in. thick	1:1	98	21.2	1,529	.22	5.9	15.6	4.6	.06
Base, ½-in. thick	1:2	240	73.5	5,293	.31	8.3	22.1	3.3	.05
Top finish, 3-32-in. thick	1:0	118	16.5	6,852	.14	3.8	57.8	7.2	.02
Granolithic Walk: Base	1:3:5	110	90	695	.82	22.2	6.3	1.2	.16
Top finish	1:1½	73	19.3	695	.26	7.1	9.5	3.8	.11

*Graven stone used in this concrete, broken stone used in remainder of concrete.
†Natural, all other Portland cement.
‡"E" concrete left 1-in. low on slopes and smoothly finished with mixture having stone dust containing particles less than ⅜-in. diameter, substituted for broken stone.
§Proportion changed from 1:1 to 1:2, as it was thought less likely to crack if more sand was used.

Fig. 5, bolted to these plates, was used in hoisting the plates into position. All calking and riveting, so far as possible, was done by pneumatic machines, power for which was furnished by a 25-HP. boiler and 12-HP. Clayton Air Compressor, carrying a pressure of 100 to 110 lbs. per sq. in. A round-nosed calking tool was used and great care taken not to injure the under plate. The use of drift pins was not allowed to force the rivet holes to coincide, any holes more than $^1/_{32}$-in. out of center being reamed. The side plates were first set up with bolts, and when all were in place the riveting begun at the top and worked downward, except in the case of the lowest two or three courses, when the riveting kept pace with the erection. The work of erection was finished Nov. 20, and on Dec. 13, 1900, all riveting was done.

The space between the bottom of the stand-pipe and the concrete foundation was filled with neat Portland cement grout, by means of a force pump, through grooves left for the purpose in the concrete foundation. In order to prevent lifting the bottom plates during this work the stand-pipe was filled with water to a depth of about 6 ft. After this grout had set, the tank was filled with water and several leaks were tightly calked. The leaks which appeared about the bottom were the most troublesome, necessitating emptying the tank and calking on the inside; finally the work was pronounced satisfactory and to-day the tank is apparently tight. The estimated actual cost of this work is:

Labor: Assembling plates		$383.35
Riveting		488.38
Calking		111.95
Painting		47.36
		$1,031.02
Cost per net lb.: Labor		0.00885
Materials and freight		0.02996
Total cost		0.03881

Estimated cost of field plant, $1,600.

MASONRY TOWER.

On May 23, 1901, the contract for erecting a stone tower about the stand-pipe was awarded to J. E. McCoy, of Boston, for $24,790. The principal items on this work as estimated from the plans were:

Rubble masonry	625 cu. yds.
Dimension stone masonry	275 " "
Iron and steel work	14 tons.
Granolithic roof	90 sq. yds.

The tower shown in a nearly finished condition by the view, Fig. 6, is about 77 ft. high from the ground to the top of the caps of the merlons. The inside of the wall is plumb, while the outside has such a batter that the thickness at the bottom is 4¾ ft.; 9½ ft. above this point, 3½ ft. thick; and 2 ft. thick just below the cornice arches. The general plan and elevation of this work is shown in Fig. 7. The merlon caps and embrasure sills are the largest stones used, weighing about 3½ tons each. Besides the general design, the principal architectural feature is the arch over the entrance. This has a clear span of 8½ ft., with a rise equal to one-half the span. Its face is curved or battered to conform with the outside surface of the wall and in this respect presents a form of arch not frequently encountered.

The contractor commenced work May 27, using two 40-ft. boom derricks, operated by hand until the wall was about 10 ft. high. Between the stand-pipe and the inside of the wall was a space 3¼ ft. wide, in which it is proposed to build the circular stairway leading to the top of the tower. In this space the contractor erected a wooden

Fig. 6. View of Masonry Tower Nearing Completion.

staging completely encircling the tower, and held securely to it by wire ropes. Across the top of the stand-pipe were placed two pairs of 4 × 12-in. hard pine timbers, 30 ft. long, trussed with 1¼-in. steel rods. These timbers rested partly on the top of the stand-pipe and partly on the staging. Over the top of the stand-pipe a plank platform was laid. This was covered with sail cloth to prevent dirt from falling into the stand-pipe. On the platform, over the center of the tower and resting on the trusses, the derrick, with which the larger part of the work was done was placed. This derrick had a 30-ft. boom, and a 20-ft. mast. It was held in place by six ⅝-in. wire guys, anchored to 14 × 14-in. hard pine uprights and deadmen 300 to 400 ft. distant from the tower. The derrick was operated by a 12-HP. double-drum engine, set on the ground about 60 ft. south of the tower. Single iron blocks, 10 ins. in diameter, with ½-in. wire falls, were used until the large stones for the top were to be raised, when a two-part block was substituted on the boom. This derrick was so pivoted that it could swing all about the tower, but on account of the leaders to the engine it could not make a second revolution in the same direction.

The cement, sand and concrete conform to the requirements of first-class work. Except as otherwise stated, uncoursed rubble masonry, laid in natural cement mortar mixed in the proportions of 1 part cement to 2 parts sand, was used for the wall of the tower. In freezing weather Portland cement was substituted for natural, and the proportion changed to 1 to 3. The stones for this portion of the work were of sound, clean Quincy granite "g... from which thin edges and projections had been ...mered. Headers constituted about one-fourth th... of the outside face, and were of sufficient size to s... strong bond with the rest of the masonry.

The exterior of the tower, the interior above the ... and a band about 8 ft. wide following the wind ... stairs, were laid to such a face that no stone projects ... than 2 ins. beyond neat lines, while in the remainin... tion of wall, no stone projects nearer to the tank tha...

In the rubble work, the stone are roughly dressed ... with joints on the face averaging ¾-in., care being ... to break joints in the courses. The steps at the ent... the base course, voussoirs of all arches, the quoins ... entrance, the sills and lintels of all windows, the belt ... at the top of lower windows, the corbels carrying th... nice arches, the sills of the embrasures, the caps of merlons and the band under the caps were of best qu... Quincy or Rockport granite. The bed joints of these st... were dressed for 6 ins. from the face, and laid w... joint not exceeding ½-in. for this distance, and a lim... 3 ins. for the remainder of joint, except in the case of radial joints of the voussoirs, where no portion of the ... exceeded 1 in. in thickness.

The dimension stones were laid with the same qua... of mortar as used in other parts of the work. The ... posed faces of the steps, the washes and tops of the sills and the bottom lintels of the large windows were six-... The faces of the sills and lintels of the small windows w... rock-faced, and the remainder of the dimension stone either rough or fine pointed. The contractor is to furnish and set all iron, wood and other work necessary to complete the tower. The roof framing is to consist of steel beams, channels and plates fitted and framed together. At the main entrance there are to be boiler iron doors stiffened with angle irons, studded with rivets and hung on forged hinges.

The stair carriages are to be made up of 5-16 × 8-in. plates, and 3 × 5-in. angles, thoroughly braced and anchored to the wall. The treads and landings are to be cast and to have suitable pattern work on the top surface. The railings and stanchions are to be of wrought iron pipe. All iron work is to be of the best quality, and the workmanship first-class in every respect. An 8-in. overflow pipe from the top of the stand-pipe and a 3-in. drain pipe from the roof, are carried down to the vault in the foundation in a chase in the wall for this purpose.

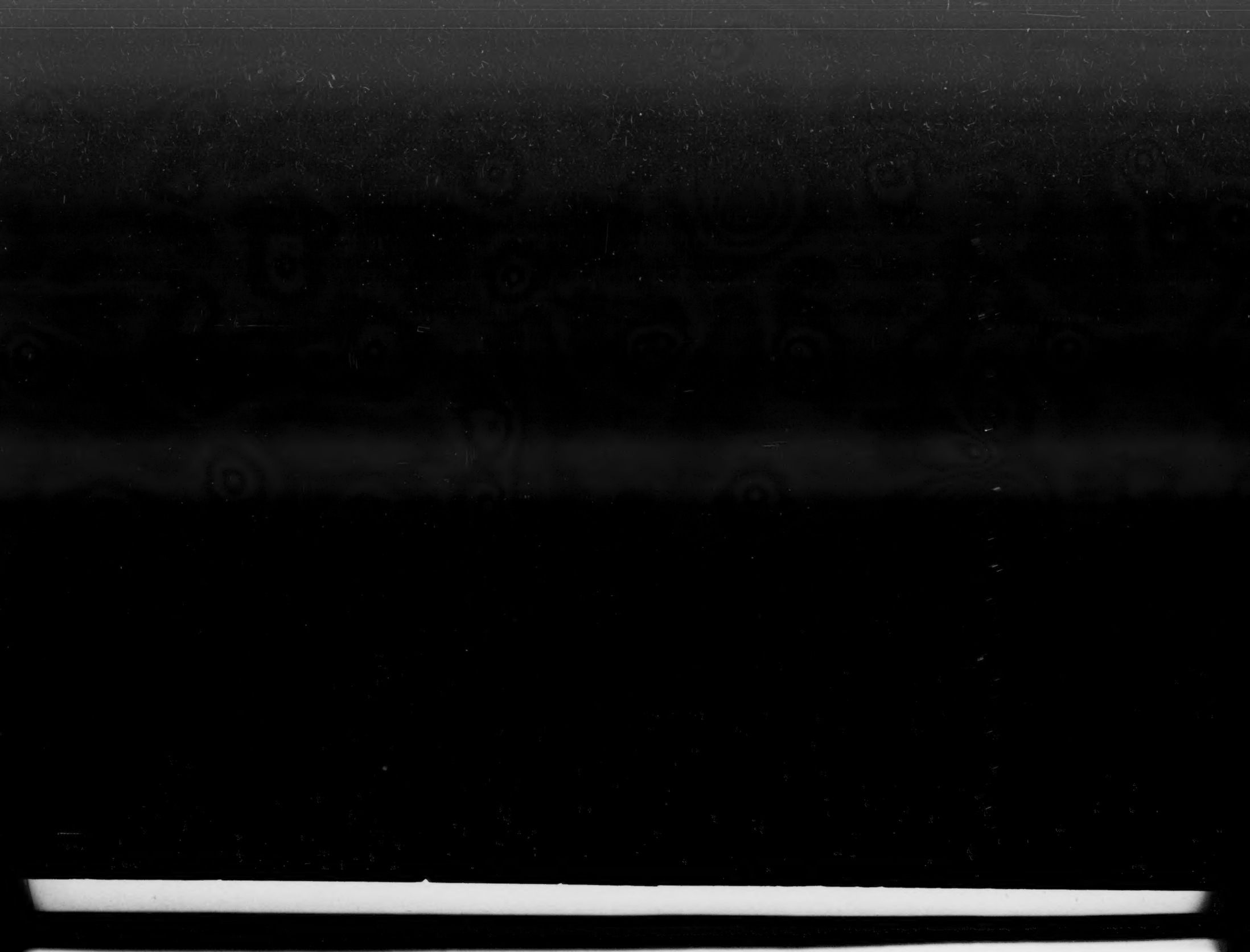
The lower windows and the transom over the door are to be protected with suitable wrought iron grilles.

The roof is to be composed of 8-in. terra cotta flat arches, "end construction," covered with Portland cement concrete, mixed 1 part of cement, 2 parts sand and 5 parts fine gravel stones. This concrete is to be covered with a ¼-in. layer of neat Portland cement plaster, thoroughly troweled and floated to make a water-tight surface, which shall pitch evenly from all directions to drainage points left through the terra cotta arches. Over the plaster layer, and next the wall of the tower, is to be laid a waterproof covering 2½ ft. wide, of 25-lb. saturated felt, lapped 3 ins. onto the wall, and flashed with 5-lb. lead. A thin layer of clean cinders is then to be spread over the roof to bring the surface to an even grade. On top of the cinder layer is to be placed a concrete layer 3 ins. thick with a granolithic wearing surface, which shall pitch evenly to the drain in the center. The intention is that if the granolithic surface cracks, water will not lodge in the roof, and then freezing, do damage, but will filter through the cinders and into the tank. This, of course, will be only in very small quantities, as the bulk of the water falling on the roof will be discharged by the drain outside the tank. The upper portion of the stairs and the landing just below the roof are to be covered with a wooden hood. Iron brackets have been let into the wall about 3 ft. below the top of the tank to carry a platform to give access to all parts of the tank, and in the roof are hatchways with iron frames and covers to afford light and facilitate entrance for work inside the tank. The stone work in this tower is now almost completed and the iron work is being erected.

TABLE IV.—Cost of Work to Commonwealth of Massachusetts to Feb. 1, 1902.

Reservoir:			
Earth excavation	30,100 cu. yds.	$11,438	
Rock excavation		52	
Concrete masonry		15,045	
Plastering		1,706	
Granolithic walk		1,313	
Seeding		21	
Railing and labor		425	
Miscellaneous—extra plastering, etc.		462	
			$30,462
Gate Chamber:			
Earth excavation	630 cu. yds.	$239	
Concrete masonry		2,232	
Granite masonry		855	
Brick masonry		116	
Pipe connections—labor		100	
Woodwork and covering of gate chamber		480	
Laying water pipes: 30 and 24-in.		30	
Furnishing same: 30, 24 and 12-in.		487	
Valves		1,289	
Specials and wall castings		509	
Stop planks, screens, float gage, etc.		253	
Iron work: Beams, manhole covers, etc.		310	
Lead, freight, etc.		55	
Labor, teaming, pipe, etc.		762	
Extra stone work		47	
			7,764
Stand-Pipe:			
Foundation—Excavation	1,355 cu. yds.	$515	
Concrete masonry		1,704	
Grouting under tank		133	
			2,352
Pipe connections:			
Furnishing c.-i. pipe, 4, 8 and 12-in.		$112	
Labor		20	
Specials and valves		208	
			339
Stand-pipe:			
Furnishg and erectg (Walsh contract)			4,530
Masonry tower:			
Fur. & erecting (McCoy contract) not completed			11,774
Total			$57,221

TABLE V.—Estimated Actual Cost of Gate Chamber.

(The Commonwealth furnished valves, pipes, special castings, iron work, screens and stop planks; excluding the cost of these but including the expense of setting the wall castings, the cost was:)

Earth excavation	630 cu. yds.	@	$0.944	$595
Concrete masonry: Class "A"	243 " "	@	6.820	1,657
Class "B"	37 " "	@	5.340	198
Granite masonry:				
Stone delivered on work			$1,000	
Cement (estimated)	8 bbls.	@	$2.23	17.84
Sand (estimated)	3 cu. yds.	@	1.13	3.39
Labor				168.68
Rent of derrick	5 weeks.			50.00
Repointing and cleaning				50.00
				1,290
Brick masonry: Labor			$60.90	
Brick, a M.	3,500	@	$10.00	35.00
Cement (estimated)	10 bbls.	@	2.23	22.30
Sand (estimated)	4 cu. yds.	@	1.13	4.52
				123
Woodwork and covering:				
Aberthaw covering	132 sq. ft.	@	1.50	$198.00
Door and frame				30.00
Hard pine lumber in floors				25.00
Hardware				10.00
Labor				38.00
				301
Total				$4,163